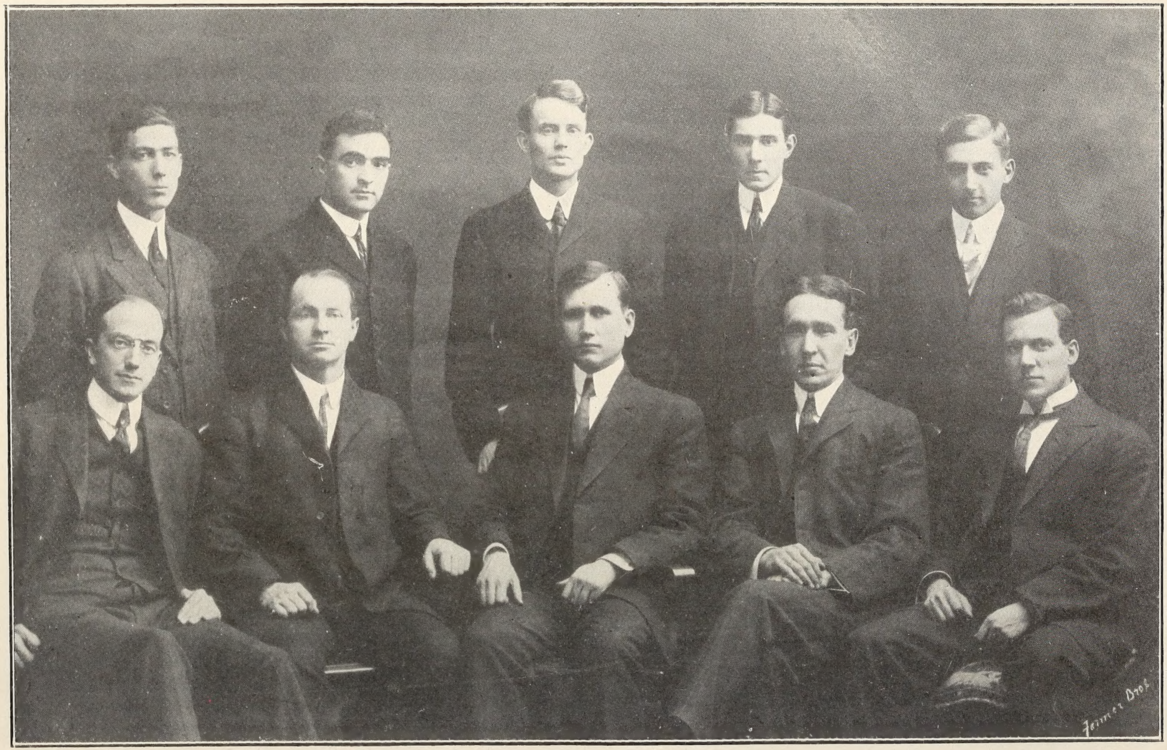

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CEMENT*

E. ASHTON HASSAN.

Gentlemen:—It is with a certain amount of diffidence that I stand here this evening, for, appearing before a number of men of your standing and ability carries with it an honor that could not be eclipsed and for the privilege of which I desire to tender my sincerest gratitude. Knowing something of the value of your time, I fear almost to present my material before you, fearing I may fail to some extent and thereby waste your valuable time, and were it not with hopes that my paper would be beneficial to most of you I never would have accepted the invitation.

History chronicles vaguely the events of a period known as the Stone Age, when men wrought with the crudest tools and implements and eked out the merest existence. But man's necessity made him progressive and his cunning taught him to devise instruments superior, of bronze, with which to serve his purpose, only to find them on further advancement inferior to the improved work of his son in the Iron Age. Each plays its part in the economy of Nature, then yields place to its betters and the Stone Age, Bronze Age and Iron Age seem to be yielding the palm to the Imperial Age of Portland cement. Apparently no product in the world has wider application than Portland cement, a man telling me a little while ago that his wife had patched up her leaky wash-tub with it some six months ago and up to date it was still in good condition.

Men are beginning to realize more and more its worth, especially with regard to its fireproof qualities, wherein brick, stone, terra cotta, iron and steel all suffer in comparison with it. The great ultimate strength that can be gotten in conjunction with steel in the form of the now widely known and yet unknown form of reinforced concrete. It is, as we heard a few weeks ago in a lecture—I refer to the "Artistic Bridge Building Design"—the ideal building material in bridge construction, whether for strength, form, beauty or durability. Probably there

*An address delivered before Chemical Section of Engineering Society, January, 1909, and awarded 1st prize for Student's Paper.

is no material on earth better adapted for street paving or sidewalks, etc., and the many objections raised are usually prompted by the inferior workmanship and lack of knowledge concerning this very important branch of construction.

In house construction, although time has not been given as yet to ornamentation, there is no limiting the possibility of cement with regard to the "house beautiful." The exhibition given during the next week will in all probability be a revelation to you in this direction. It has been treated to very good effect, as might be seen in the buildings of St. James Church, Brooklyn, N.Y., club house of Detroit Boat Club, Nassau County Court, Mineola, Long Island, and very many others, a few illustrations of which are here for your approval.

While once the structural steel buildings were thought absolutely fireproof and safe, it is now almost universally conceded that it must be supplanted by reinforced concrete. There seems little doubt but that Portland cement has made work of such magnitude as the Assuan Dam, the marvellous docks of Buenos Ayres and the Panama Canal, engineering feats capable of being successfully handled.

It might be well for us to note with what rapidity the manufacture of this product in the United States and Canada has grown. In the United States, in 1892—547,440 barrels; value $1,153,600; 16 plants; in 1904—26,505,881 barrels; value $23,-355,119; 75 plants; in 1908 it had reached 49 millions. I take my last figures from the paper recently read before the Canadian Engineering Society by Dean Galbraith.

While not being able to quote the exact figures for Canada's production, from the business in which we have been engaged during the last few years, it has at least been increased about one-and-a-quarter million barrels and with the two new plants here in Ontario and two near Montreal, you will be able to judge for yourselves its growth.

Year	Canadian Barrels.	Imported Barrels.	
1904	910,358	784,630	1,694,988
1905	1,346,548	917,558	2,264,106
1906	2,119,764	694,503	2,814,267
1907	2,436,093	672,630	3,108,720
1908	2,665,289	457,408	3,122.697

Detailed statistics for past two years are as below:

	1907	1908
Portland cement sold	2,436,093	2,665,289
Stock on hand Jan. 1st	299,015	383,349
Portland cement manufactured	2,491,513	3,495,961
Stock on hand Dec. 31st	354,435	1,214,011
Value of cement sold	$3,777,328	$3,709,063
Wages paid	956,080	1,274,638
Men employed	1,786	3,029

There are about twenty-three plants in Canada, of which twelve use marl and clay and ten use limestone and one slag.

Nor can we say that this remarkable progress is to end here, for many have been the calls for the erection of plants, and one firm capable of nearly 3,000 barrels per day capacity, have if their machines run at their full capacity day and night until the end of the year, sufficient orders now to take all they make, and are thus seriously considering the duplication of their plant. If you will pardon an interpolation at this point, may I say that it is an erroneous conception of the manufacture of cement that has led people to believe that plants can be erected and worked profitably on a small scale and at small cost, and to disprove this theory will be in some respects the aim of this paper.

It would be advisable that we at this juncture acquaint ourselves with the material under discussion and find out what Portland cement really is.

There appeared in the Crawford (Nebraska) Tribune in 1906, an article in which the editor, evidently mutilating the words of Prof. Barbour of Nebraska, said: "Nebraska has almost inexhaustible beds of impure limestone, which is the material used in the manufacture of cement, but at the present prices of fuel this wealth of building material cannot be manufactured at great profit. The process of manufacture is very simple. Impure limestone mixed with sand is ground up and water added to make a thick paste. This flows through an iron pipe heated to a white heat so that the paste becomes dry and finally emerges from the end of the pipe as clinkers, which fall into a stone crusher, and pass between rollers, the dust falling into sacks ready for market." Now, gentlemen, this may be an exaggerated case apparently prepared for the mind of a western cowboy, nevertheless something of the above state of affairs exists quite largely in the large and busy cities of this country with regard to Portland cement and its manufacture, a school man asking me a few days ago if plaster of paris was put in to make cement harden.

Cement may be said to be a material which when pulverized and mixed with water into a paste, acquires the property of setting and hardening under water.

In engineering construction three kinds are known: Pozzuolana cement, natural cement, and Portland cement. Pozzuolana is obtained by grinding together an intimate mixture of slaked lime and blast furnace slag or volcanic scoria. The cement is not burned, the hydraulic ingredients being present only as a mechanical mixture, hence it never gained general acceptance. This must not be confused with slag Portland, which is regular Portland, the slag furnishing the silicious ingredients, taking the place of shale or clay in the mix.

Natural cement is the product resulting from the burning and subsequent pulverization of argillaceous limestone or other suitable rock in its natural state, the heat of burning being sufficient to cause vitrification. If, gentlemen, there were more

time at our disposal, I might be inclined to give this a further consideration, but it must of necessity, owing to the title of my paper, be relegated to the background with a hope of further study on some future occasion.

Portland Cement.—In what follows in this paper the discussion will be now limited to Portland cement, so that whenever the unqualified term "cement" is employed, Portland cement alone is to be understood.*

Le Chatalier in 1897 published as his thesis for the degree of Doctor of Science a dissertation upon "The Experimental Study of the Constitution of Hydraulic Mortars," in which he propounded a theory that Portland cement was composed of two essential compounds, tricalcium silicate $3CaOSiO_2$ and tricalcium aluminate $3CaOAl_2O_3$. (Journal Soc. Chem. Ind. XI, 1035.) Spencer B. Newberry ten years later confirmed the views of Le Chatelier concerning the tricalcium silicate, but held to the theory that the alumina was present as dicalcium aluminate $2CaO.Al_2O_3$. In 1906, Day and Shephard (Am. Chem. Soc., XXVIII, 1089, also Chem. Eng. IV, 273) read a paper before the American Chemical Society in which they stated that no such compounds as tricalcium silicate exists and that the compound so called by others is a mixture of lime and orthosilicate (dicalcium silicate). We thus find within twenty years three radically different theories and we would expect that these revolutions of theory would have some influence upon the practical manufacture of Portland cement and the ultimate composition of the commercial product.

R. K. Meade analyzed a sample of cement in 1896 and one in 1906 and says: "I doubt if both samples had been drawn at either time, from cement made a few days apart, they could not have agreed more closely."

It must not be supposed, though, from what I have just quoted that cement is not better to-day than ten years ago; that would be fallacious, for in fact it is on an average very much better, but this progress has been due to the improved mechanical appliances rather than to any new ideas of how to make Portland cement, especially with regard to the fine grinding of the raw materials.

The generally accepted theory concerning Portland cement, which by the way is taught in the School of Practical Science, is the one propounded by Newberry, and which leads us as follows: Assuming that the trisilicate and dialuminate are the most basic compounds which can exist in good cements, we have the following formula: $X\ (3CaOSiO_2) + Y\ (2CaOAl_2O_3)$ in which X and Y are variable quantities having different values according to the relative proportions of silica and alumina present in the clay employed.

*Ref.—Annoles des Mlnes, 1887, p. 345, also translation by J. L. Mack; McGraw Publishing Company, New York.

The formula $3CaOSiO_2$ corresponds to 2.8 parts of lime by weight to 1 part of silica.

The formula $2CaOAl_2O_3$ corresponds to 1.1 part of lime by weight to 1 part of alumina, and substituting weights for equivalents we have what is known as Newberry's Hydraulic Index, representing the maximum of lime which should be present in a correctly balanced cement. % lime = % silica × 2.8 + % alumina × 1.1. If we take lime and silica in the proportion of 2.8 and burn them thoroughly, we get hydraulic properties slow setting but ultimately developing great strength. We would draw from this the conclusion that the tricalcium silicate contributes to the cement its ultimate strength and hardness.

On the other hand, treat lime and the aluminate in their proportions above named, burn them thoroughly and on pulverization we get material which exhibits quick-setting properties and we thus judge that the dicalcium aluminate contributes to a cement its quick-setting properties, and that a cement high in the aluminate will be a quick-setting cement. Now taking the formula and using it to calculate the proportion of lime to be used for a clay of a known composition, we proceed: × % of silica by 2.8, the Al_2O_3 by 1.1, add the products; the sum will be the number of parts of lime required for 100 parts of clay.

As 2.8 parts of lime correspond to 5.0 parts of carbonate of lime and 1.1 parts of lime corresond to 2.0 parts of carbonate of lime, the calculation for factory work takes the following simple form: 5 times the % of silica + twice the % of alumina = the number of parts of carbonate of lime required for 100 parts of clay. A practical example: Suppose a clay on analysis had this composition: Silica 65.4, alumina 16.5, iron oxide 6.1, lime 2.2; magnesia 1.9; moisture, etc., 7.9; total 100. Let us calculate the amount of lime or carbonate of lime which must be added to this clay to produce a lime correct cement mixture.

% silica = 65.4 × 2.8 =	183.12
% alumina = 16.5 × 1.1 =	18.15
	201.27
Less lime in clay	2.20
	199.07 parts lime for 100 of clay.

As 56 parts of lime correspond to 100 of carbonate of lime we have $\frac{199.07 \times 100}{56} = 355.5$ parts of carbonate of lime for 100 parts of clay, the correct mixture now reading:

Clay, 100 parts.

Pure $CaCO_3$ 355.5.

The % of carbonate of lime in this mixture would be 78%. On burning this a high grade cement would result, providing the raw materials were very finely ground and perfectly mixed and fully calcined.

You will understand, of course, that this represents, as was previously stated, the maximum of lime that may be used in safety.

Seeing that of late date magnesia and iron are allowed for, a correction by the way which seems advisable, I will endeavor to give the steps for proportioning a cement mixture accordingly.

Operation 1.— $\times$ % of silica in clayey material by 2.8, the % of alumina by 1.1 and the % of iron oxide by 0.7; add the products; subtract from the sum thus obtained % of lime oxide in the clayey material plus 1.4 times the % of magnesia. Call the result n.

Operation 2.—Multiply the % of silica in calcareous material by 2.8, the % of alumina by 1.1 and the % of iron oxide by 0.7; add the products and subtract the sum from the % of lime oxide plus 1.4 times the % of magnesia in the calcanous material. Call the result m.

Operation 3.—Divide n by m. The quotient will be the number of parts of calcareous material required for 1 part of clayey material. Example:

Assuming the following compositions of

	Clay	Limestone
Silica SiO_2	62.2	2.4
Alumina Al_2O_3	16.1	2.0
Iron oxide Fe_2O_3	4.2	0.3
Lime (CaO)	1.6	50.2
Magnesia (MgO)	1.2	1.5
Sulphur trioxide (SO_3)	1.7	0.6
Alkalies ($K_2O.Na_2O$)	0.8	0.4
Water, CO_2 etc.	12.2	42.6

Operation 1. Clay—

Silica	$\times 2.8 = 62.2 \times 2.8 =$	174.16
Alumina	$\times 1.1 = 16.1 \times 1.1 =$	17.71
Iron oxide	$\times 0.7 = 4.2 \times 0.7 =$	2.94
		194.81
Lime	$\times 1.0 = 1.6 \times 1.0 =$	1.6
Magnesia	$\times 1.4 = 1.2 \times 1.4 =$	1.68
		3.28

$\therefore$ $194.81 - 3.28 = 191.53 = n$.

Operation 2. Limestone—

Silica	$\times 2.8 = 2.4 \times 2.8 =$	6.72
Alumina	$\times 1.1 = 2.0 \times 1.1 =$	2.20
Iron oxide	$\times 0.7 = .3 \times 0.7 =$	0.21
		9.13

Lime	$\times 1.0 = 50.2 \times 1.0 =$	50.2
Magnesia	$\times 1.4 = \ 1.5 \times 1.4 =$	2.10
		52.30

$\therefore \ 52.30 - 9.13 = 43.17 = m.$

Operation 3.—

$$\frac{n}{m} = \frac{191.53}{43.17} = 4.44 \text{ parts of limestone}$$

to be used for each part of clay by weight.

Again let me remind you that the value given by the above formula represents the highest amount of lime theoretically possible, and under best conditions procurable at the present stage of the industry one needs to reduce this about 10% to get satisfactory results and we may therefore safely state according to above that

4.44 = parts limestone to one of clay.
0.44 = 10% reduction for safety.

4.00 = parts of limestone to 1 of clay to be actually used.

I would like to have given examples to you of the physical tests, but as these are taught in the university you will no doubt at a later date come into intimate contact with them.

Chemical analysis of the finished product is rarely resorted to as hardly any adulteration takes place owing to the fact possibly that it is just as easy to make good cement as a poor one, providing parties have sufficient knowledge of the essentials of its production.

I feel that I have hardly done justice to the most important phase of cement, namely the chemical, but I have attempted in a brief way to bring before your notice its composition and it will, I would presume, stimulate a greater interest in the discussion concerning its manufacture. Speaking personally, I do not feel in any way competent to discuss at great length the subject of which I am here to learn.

We are now fully prepared to deal with the raw materials, and one word here of warning; probably some of my hearers will be called sooner or later to pass judgment upon deposits of marl, lime, clays or shales respecting the advisability of putting in a cement plant. A great responsibility therefore rests upon such a one, and a few important things to bear in mind are:

1. Chemical composition of the material.
2. Physical character of the material.
3. Amount of material available.
4. Location of the deposit with respect to transportation routes.
5. Location of the deposit with respect to fuel supplies.
6. Location of the deposit with respect to markets.

Just a word with regard to No. 3, amount available. A plant running on dry raw materials such as a mixture of lime

per kiln; of this about 15,000 will be limestone, 5,000 shale. and shale will use about 20,000 tons of raw material per year Assuming limestone weighs about 4,400 lbs. per yard and the shale 3,300 lbs. per yard, let us remember it would be folly to erect a plant on property with less than twenty years' supply. For each kiln of the proposed plant, then, there must be in sight at least 3,800,000 cubic feet of limestone and 1,600,000 cubic feet of shale.

With regard to fuel supplies, let us remember each kiln with the requisite crushing machinery uses up from 6,000 to 9,000 tons of coal per year.

There are two modes of manufacture of cement, the dry and the wet process, the difference in short being that in the dry process the material enters the kiln dry, while in the wet it is pumped into the rotary as a slurry. Many men have thought that using wet marl constituted the wet process, but such is not the case, for if the mix be dried previous to its entering the rotary it is called the dry process.

Taking the case of a limestone and clay. The limestone is quarried usually by blasting with dynamite and the opening should be so located as to give as little stripping as possible, for stripping is merely dead work, adding greatly to the expense of the product. The prevailing practice is to open up the quarry on a low hillside, so as to give a long working face and blast down in benches. The rock is sometimes loaded in cars hauled by locomotive or horses to the mill, but the better way is to have a cableway installed of the type to be shown in one of the slides, which has a great advantage and is called a twin cableway, and the two towers farthest from the mill are on rails so that they may be moved in any direction and thus facilitate the handling of the rock, also use of two buckets.

In a plant recently erected where the limestone is on the mountain side, the shelf has been cut sufficiently high to allow sufficient grade for cars to run down to the crusher by gravity and situated at the crusher dump is a short car haul lifting the cars onto a trestle bridge where they receive sufficient impetus to go back to the quarry without further aid. This has proved possibly the cheapest method of handling, but natural advantages of this description are not always obtainable. The material is dumped into a Gates crusher or one of similar type, the modern method employed by the largest plants in Canada being to have a No. 7 Gates crusher, the material falling from this into a perforated revolving cylinder, the pieces not going through the perforations falling down into a No. 4 crusher, the aim of the manufacturer being to get the rock into pieces from 1½ to 3 inches in size to make them easier to dry, the material having a like area submitted to the heat, all then being uniform with regard to moisture.

Provision is made for the storage of hundreds of tons of the rock so that in case of bad weather when men cannot work

in the quarry, the mill will not suffer and sufficient is usually stored for seven days' run.

The first crusher will take rocks up to 18"x45", and is capable of breaking about 120 tons per hour to 2½", driving pulley running about 350 R.P.M. with a 110-h.p. motor and is worth about $6,000; while the No. 4 will take the pieces from the cylinder and handle them with a 50-h.p. motor very easily, the price of this being about $3,000. The two motors will cost about $2,000.

The rock is taken from the storage by the same conveyor used for filling the storage, the best type being what is known as the Peck overlapping bucket conveyor, which is essentially an endless chain of buckets, each pivoted to a bar so that they might swing on their central axis and maintain an horizontal position when running up the towers. This conveyor runs about 150' per minute and is worth, installed, about $15 per foot, and is without doubt the most expensive style of conveyor in modern use, but its perfect running and the fact that it never gives occasion for stoppages fully warrant the initial expenditure.

I will endeavor to explain the different modes of conveying and their relative values by means of the slides later.

The material is carried by this to hoppers placed above a dryer, which is, as you will see by drawing exhibited herewith, an iron cylinder about 5' in diameter and 50' to 80' in length, set at an inclination of about ¾" per foot, turning at three revolutions per minute. Inside are four plates (perforated) projecting out from the sides to within eight inches of the imaginary centre. The material is fed through a water-jacketed cast-iron pipe and fire applied by means of a furnace whose gases play directly into the dryer. From this the dry rock is elevated to the Ball mills for grinding. There are several types of pulverizing mills which are used at this stage, one well known and at one time largely used being the Griffin mill, of which I will show a picture later and which I will then describe. There is also the Kent mill, Huntingdon, Lehigh pulverizer and Kominuter. Ball mills are made by a number of manufacturers but the types mostly found in cement plants are the Schmidt, Gates, and Krupp; there is very little difference in their mechanism. I have here for your notice drawings of a Ball mill. The machine has a through shaft with journals running in bearings at both ends. The machine consists of a drum with two strong end plates between which curved drum plates are fixed. These plates do not form a cylinder, but one end of each is set a few inches nearer the centre, thus forming steps, the balls and material falling over these steps when the drum revolves and thus the material is pounded. The drum is surrounded externally by a fine cylindrical phosphor bronze or steel wire gauze fit in narrow sections so that they may be taken out and replaced with finer gauze according to degree of fineness required; the ones often used are 20-mesh $125 phosphor bronze wire open

.05 — 016 = .034″. Each section requires piece of screen 27″x51″ and twelve to each mill.

The Ball mill contains iron balls as follows: 87 5″ balls, 18 pds. each; 128 4″ balls, 10 pds. each; 300 3″ balls, 5 pds. each; net 4,366 lbs.

The drum revolves at 21 R.P.M., requires a 75-h.p. motor and can grind to a residue of 76.2% on a 100 sieve 21 barrels per hour. A Griffin mill will reduce about 5 bbls. per hour to 95% pass a 100 mesh.

From the Ball mills the rock is transferred by means of a screw or spiral conveyor to large steel wood-lined bins. Experience has led us to always keep steel from contact with the rock or cement as the steel sweats and moisture is thus imparted to the material, while the main idea is to keep it dry. It is during its storage in this bin that the rock samples are taken and analyzed, the bin being partitioned off into six divisions. After analysis it is ready for the scales. While this process has been going on a similar process with the exception of the use of a Blake crusher for reducing to size, has been going on with the clay, and we find bins of like manner but much smaller now filled with coarse ground clay which is awaiting the verdict of the chemist. After the report has been received from the chemist the materials as per his instructions with regard to weight, are now weighed.

From the weighing hoppers the two materials are dropped simultaneously into a screw conveyor which to some extent mixes the two, which is now called the "mix." The mix is elevated and conveyed to hoppers above the tube mills and is automatically fed into them, and by constant turning in the tube becomes perfectly mixed as well as perfectly pulverized.

The tube mill is a cylinder usually about 5′x22′. It is filled to 4″ above centre line with flint pebbles. The mill makes 27 R.P.M., contains about 11 tons of pebbles and requires about 64-h.p. motor. They will grind that 95% pass 100 mesh and residue a 20 mesh. Their capacity is about 13 bbls. per hour, but here are records in which a mill ground 5,854 yards in 963 hours, or 6.07 yards per hour; on another occasion 8,493 yards ground in 1,357 hours, or 6.2 yards per hour. A mill is worth about $2,500 and thus with Ball mills at $4,500 a battery will figure installed at about $10,000.

and is taken to an elevator and lifted to a large bin standing

The mix leaves the tube mills, falls into a screw conveyor above the rear end of the kilns.

We have now arrived at the most important branch of Portland cement production. Given the best chemists and an absolutely perfect mix for combination, carelessness at this stage would prove disastrous.

The rotary kiln as at first used in cement manufacture was only 40′ long and at Sandusky, Ohio, some sixteen years ago two were joined together and new gearing placed in under the

superintendence of R. D. Hassan, in conjunction with our foremost cement chemist, Mr. S. B. Newberry. This so revolutionized the manufacture that engineers in the cement industry after visiting Sandusky immediately adopted it and it has been little changed since.

I have here drawings of the friction wheels and driving gear as they are used to-day.

The 80′ rotary, then, is practically the most universal, although at present time we are using 90′ and will in the next factory put in 100′ kilns. Allow me to here state that where the wet process is used the longer the kiln the better, and 150′ is about the most economical for such purposes. They range from 6′ to 9′ in internal diameter. Lined with very resistant fire brick about half-way down the kiln from 6″ to 10″ in depth to withstand both the high temperature to which its inner surface is subjected and also the destructive action of the molten clinker. Our present kilns are not always of equal diameter throughout, some being smaller at the stack end, accomplished by means of a reducing section just beyond the middle in the shape of a frustum or cone.

The theory being based on the gases cooling as they near the upper end should be confined to a smaller area to keep their efficiency.

With a 90′ rotary pushing it very hard it is possible to get 240 lbs. per day.

For the firing of the kiln and burning of the cement, oil, gas and coal have been used. Natural gas is used in some plants both in the States and here in Ontario, and the chief objection is that you cannot force a kiln with gas like you can with coal. Oil is generally accepted to be the best and was certainly at one time the cheapest material for burning cement, 1 gallon of oil being equivalent to 12 lbs. of coal, or 1 lb. of oil = 2 lbs. of coal.

The question of fuel consumption is the one which agitates the mind of the cement manufacturer and it is in this feature possibly more than any other which offers best prospect of improvement in the matter of economy. Owing to diversity of conditions at different factories a calculation can only be approximate. The amount of coal used in burning a barrel of cement is about 110.120 lbs. for dry material and 150 to 160 for wet material 50% water.

The actual burning of cement consumes a definite amount of heat which is absorbed in evaporating, the water contained in the material heating up the dry mixture, decomposing the carbonate and sulphate of lime present, heating the gaseous products to the stack temperature and finally heating the calcined material to the point of sintering. As the specific heats of decomposition of all these substances are known it is possible to calculate approximately the number of heat units and amount of fuel which should theoretically be required to produce a barrel of cement under various conditions.

Let us assume the use of a coal which has a theoretical value of 13,400 heat units and for its combustion requires 10.2 lbs. of air per pd. of coal. Assuming that the temperature of the kiln building is 70° F. and products of combustion escape as they often do at 1500°, we will work out that

2.75 lbs. CO_2 sp. ht. .22 at 1500 =	871
.464 lbs. water sp. ht. .48	321
8.065 lbs. N. sp. ht. 24	2,794
	3,986

If 50% more air be added than theoretically required this will absorb 1,763 h.u. The available heat of 1 lb. of this coal will therefore be 13,400.

Products of combustion consume 3986, then heat units available with theoretical air will be 9414 and 50% more air consumes 1763; the heat units available with 1½ theoretical air will be 7,651.

Let us now assume the mix is $CaCO_3$ 75%, SiO_2 15, alumina and iron oxide 5, mg. and alkalies 2.0 combined, water 2.0, SO_3 1.0. 600 lbs. of this mix will give 384 lbs. of cement, the balance representing CO_2 water and SO_3 passing off in gaseous form at stack temperature.

The heat units will therefore be the mix introduced at the upper end in the form of dry powder and the clinker discharged white hot at a temperature of about 2,500° *F.* and the gaseous products leaving the kiln at 1,500° *F.*

450 lbs. of carbonate of lime decomposed at 765 . .	344,250	54.7
12 lbs. of water evaporated and heated 60° to 1,500°	20,832	3.3
6 lbs. of sulphuric anhydride liberated at 1,890 . .	11,340	1.8
600 lbs. of mix, heat 60° to 1,000° sp. ht. .2 . .	112,800	18.0
384 lbs. of clinker heated 1,000° to 2,500° sp. ht. .2	115,200	18.3
204 lbs. of carbon dioxide and sulphur dioxide heated 60° to 1,500° at .24 sp. ht.	24,480	3.9
	628,902	100

∴ coal required per barrel of cement

With theoretical air supply 628,902 ÷ 9,414 = 66.9 lbs.

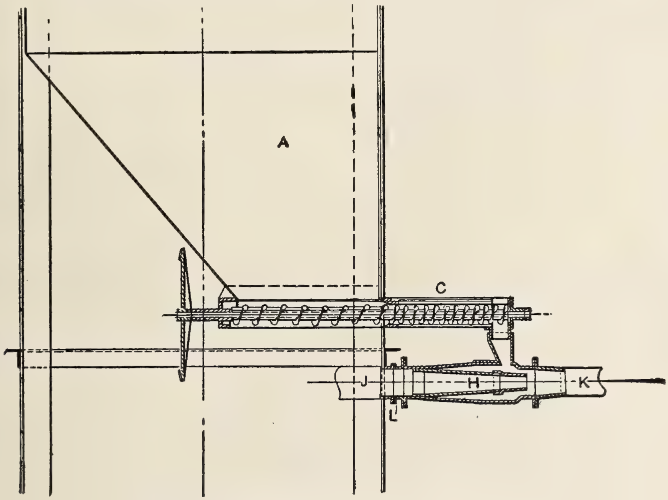
With 1½ times theoret. air supply 628,902 ÷ 7,651 = 82.2 lbs

Actually used by us in manufacture, 120 lbs.; difference about 40 lbs.

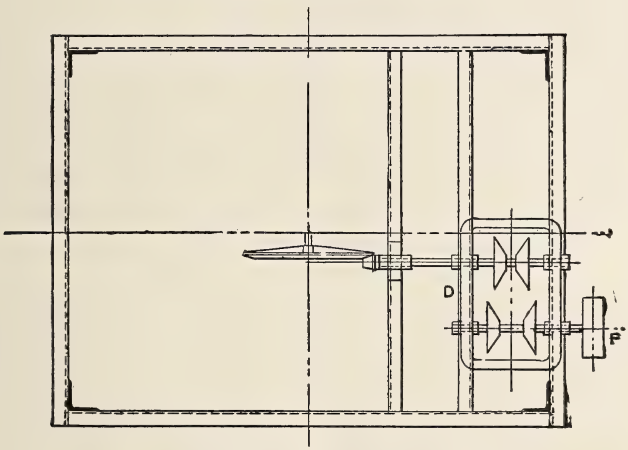
The above computations are only approximate, but you will readily see that the clinker discharged at 2,500° *F.* will if cooled to 60° give up about 185,000 heat units or enough to heat the theoretical air supply from 60° to 1,143 or 1½ times the theoretical air to 932°. With this in mind the clinker is allowed to drop into a pit from whence the gases and hot air are conducted by means of ducts to the fan for air supply and also to the coal grinding department for use of drying the coal, the hot air being

allowed to escape into a rotary drying kiln in which the coal is being passed through.

There is, of course, the gas of the stack yet to deal with, and this could be utilized in much the same way by leading it back over the kiln and using it for air supply, but the foremost cement expert is anxious to keep abreast with the times and is sacrificing



DETAIL ELEVATION OF FEEDING MECHANISM



DETAIL PLAN OF VARIABLE SPEED MECHANISM

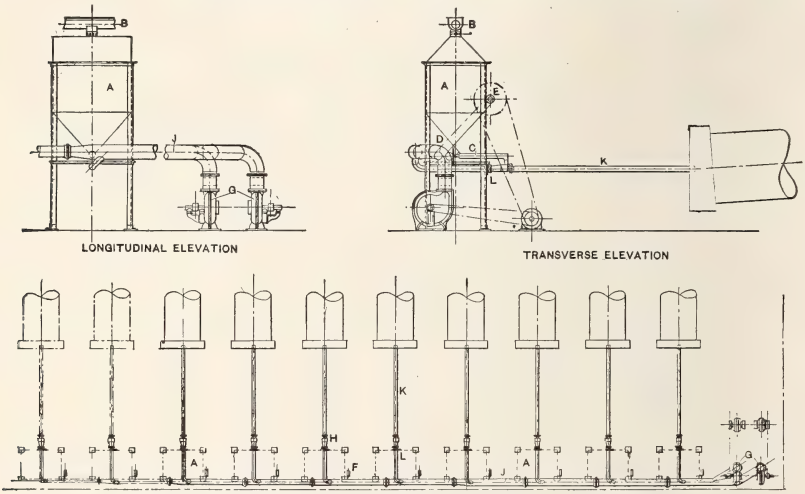
Coal-burning Arrangement, International Cement Co.

at the present time these gases, engaging himself in the design and perfecting of a mode of burning cement by electricity, in which I naturally wish him every success.

The method of feeding the coal into the kiln I will explain by means of a slide later.

Although some seven or eight years ago the clinker on leaving the kiln was run into towers or cylinders for cooling, the modern method is to transfer it to a storage and let it cool gradually itself, capacity being made for about 100,000 barrels. These bins are filled by means of a continuous conveyor which runs in a tunnel below, then up a tower and covers the entire distance of the rotaries, thereby can be made to dump the clinkers into any part of the storage, so that while one end is being filled with hot clinkers, the cold is taken from the opposite end to the Ball mills for grinding.

After the preliminary grinding by the Ball mills, the material is conveyed to scales, where the right proportion of calcium sulphate or gypsum is added to retard the setting. Just a word here with regard to the addition of gypsum. The high limed clinker which is produced in the rotary process is naturally very



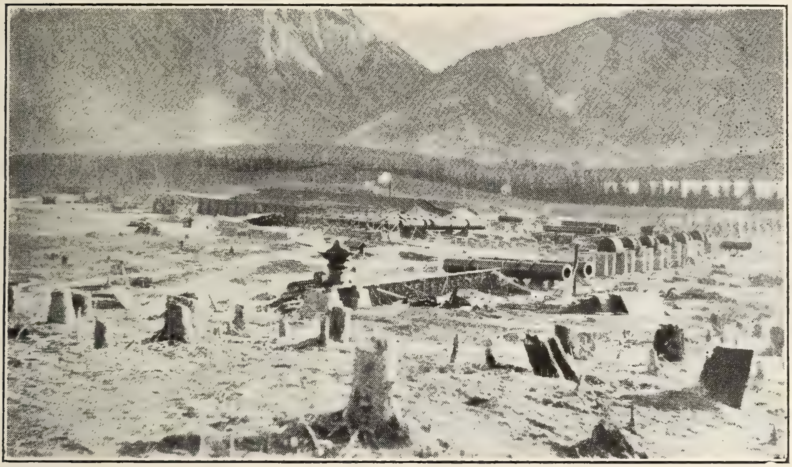
Coal-burning Arrangement, International Cement Co.

quick setting and in order to retard this somewhat, sulphate of lime in the form of gypsum is now universally employed. If added in quantities from 2 to 3 % it retards the set of the cement proportionately, and, strange to say, increases slightly the tensile strength, but in greater quantities its retarding influence becomes less and finally negative. Considerable discussion has taken place as to in which form the calcium sulphate should be added. Crude gypsum is natural hydrous sulphate of lime, formulae $CaSO_4 + 2H_2O$. Plaster of Paris is obtained by heating gypsum at 350 to 400° *F.*, the result being that three-fourths of the H_2O is driven off and we have $2CaSO_4 + H_2O$. If this be calcined at temperature above 400 we get the anhydrous plaster or simply $CaSO_4$. A misleading statement has been made, which is in brief that plaster of paris because of its greater

chemical activity will be more effective than gypsum, weight for weight. The fallacy involved is revealed when it is considered that the calcium sulphate added to the cement has absolutely no effect until the mixture is gauged with water; and this addition of water will naturally reconvert the plaster of paris immediately into the hydrous lime sulphate, gypsum. Any argument based on relative chemical activity, so called, is therefore fallacious and the sulphate is usually added as gypsum, corresponding to formula $CaSO_4 + 2H_2O$.

The mixture going through the tube mills becomes intimately mixed and is ground to finished product and then conveyed to the warehouse, where provision is made for about 100,000 lbs.

The bins are usually of plank construction, starting with



Exshaw Cement Plant under construction, showing machines on foundations

layers of 2x10 for about four feet, then 2x8, then 2x6, and 2x4 to finish. The material is thus kept from moisture. For preparing for shipment it is conveyed by means of a spiral or belt conveyor in a tunnel to packing room, where it is elevated to hoppers under which are placed scales working automatically, and although their capacity is to bag four per minute, I have run them at six per minute for a considerable period.

In this country a bag contains 87½ lbs., while in the United States they are shipped at 95, four bags to a barrel making a Canadian barrel 350 lbs., and the American 380 lbs.

We have made cement at as low as 55¾ cents per barrel, but if you make them for 90 cents it is considered good work.

A modern six-rotary plant will cost about $800,000, and with a reserve amount of $25,000 per kiln to allow for time, etc., to

put the cement on the market, you will readily understand that a million dollars is about the necessary capitalization for a plant to be built and operated successfully. Although we have only built two plants in this country they are the largest and acknowledged to be the best equipped and most modern in the country. One of them last year closed the financial year showing a payment of 18% dividend with $68,000 put to a sinking fund, bringing that up to $250,000.

Never having one bag of cement returned is the record, due I believe to this fact, that the materials during the different stages act so treacherously that it can be said upon the chemist literally hangs the responsibility. I am about to show a diagram showing with what completeness the materials are tested. You will notice sixteen separate tests are made and these through improved storage capacity are made each hour. The samples are being constantly collected. I will show the method.

The two raw materials are correctly analyzed and accurately proportioned before they enter the mill, then a distinct bin analysis is made before mixing.

It is an utter impossibility to produce a uniform Portland cement without a definite mixture of the ingredients or raw materials, hence the great importance of a perfect chemical and mechanical arrangement to accomplish this purpose.

By reason of the prominent place Portland cement now holds in the building arts, more attention is being given to quality by the architect, engineer and builder than ever before in the history of the industry, and it may reasonably be predicted that in the near future the government will inspect and grade cements as they now do other commercial commodities.

NOTE.—During the lecture numerous slides were thrown on the canvas and raw materials in various stages of manufacture were handed around for inspection.—ED.

NOTES ON THE CONCENTRATION OF SLIMES

F. C. DYER.

If we shake some crushed rock with water and allow it to subside, we notice a coarse part settles almost immediately—that we call "sands"—and another portion that settles but slowly, and is termed "'slimes."

The terms "sands" and "slimes" are two convenient but loosely applied words. Some writers say "slimes" when fairly coarse sand is included, others restrict the word "slimes" to that finest portion of all, that settles with extreme slowness.

Canvas is peculiarly adapted to catch fine slimes. Mechanical difficulties in making it travel over rollers in belt machines have hindered its use to some extent. Vanners are on the market with canvas belts. Either as a stationary intermittent table or as *slowly* travelling continuous belts it is able to catch smaller particles than any other table..

An attempt was made to observe the movements of particles on a canvas table, with a low power microscope.

It was noticed that the rough hairy surface caused the bottom layer of water to move with unusual slowness favoring the settling of fine particles.

2. The small ridges formed by the crossing of the warp and woof act as riffles, collecting the concentrates, but owing to the slowness of the water at the bottom the cleaning was imperfect.

3. The loose fibres entangle mechanically fine particles that would otherwise float off. Both ore and gangue particles are caught, hence the concentrates from a canvas table are rather lower grade than from other tables. Against this may be set the facts that canvas tables are cheap and catch what would be otherwise lost.

Measurements were made of the size of the smallest particles a canvas table would catch. The same ore was used as in other tests. The coarser slimes were taken out with a slime table. The canvas table had just slope enough to carry off the visible white quartz tailings.

The concentrates were sluiced into a pan, allowed to settle three minutes, and the water with the fine particles in suspension poured off. These particles were given time to settle and measured with a micrometer microscope.

The average diameter was .19 mm or about .0075 inches. With concentrates of greater specific gravity, finer particles still would probably be caught.

The Wilfley slimer, though a canvas table, is painted The hairs are "layed" and the "riffles" partially filled up, therefore probably it cannot catch such fine particles as fresh canvas surfaces.

The rubber belts of Vanners are sometimes finely corrugated or riffled to catch more concentrates.

If the waters in the launders and on the tables is carefully examined it will almost always be found to have particles of concentrates floating on its surface.

If by any chance the concentrates become exposed to the air, as soon as the water again touches them a stream of concentrate particles will float out on the water.

This paradoxical floating of high specific gravity particles on water of low specific gravity is the misnamed Greasy Flotation.

Though small at any particular place, this loss multiplied by the long time it operates may amount to a serious quantity in the operation of a large mill.

Sometimes an inclined blade dipping below the surface of the water is placed across launders to force floating particles below the surface. [1]

The term "floating" here always refers to particles swimming *on* the surface while "suspended" refers to particles swimming *below* the surface.

A more serious and difficult loss to prevent occurs in the suspended particles.

Since the volume of a sphere diminishes as the cube of the radius and the surface only as the square, a point must be approached when the resistance to a particle settling, which depends on the size of the particle, must approximately equal the weight which depends on volume. The closer this approximation, the more slowly the particles fall.

The reasons for slow settling of fine slimes are referred to later.

Since a sphere has a maximum volume for a given surface suspended particles of different shape may be comparatively large and have a slower settling rate than spheres.

To illustrate the loss that occurs in the various sizes of particles, an ore of chalcopyrite and quartz was sent over the tables. The ore was crushed under stamps, the coarse sands removed by a classifier and sent to a Wilfley table. The fines were sent to the slime table. Samples of the feed and tails were taken at intervals. They were dried screen sized and weighed. The assaying was done by the Guess-Haultain electrolytic method.

In the drying the finest particles tend to flocculate and even to form hard lumps, and to stick to the larger grains. Gentle rubbing was employed to disintegrate the floccules, but the weights are only approximate, the finest size through 200 mesh probably being most underweight. If great accuracy were required elutriation methods would be necessary. The assay value of the finest sort will be correct, that of the others slightly high.

1 Callow. Mining, Vol. III, p. 94.

The following table shows the weights and value of the feed to a slime table:

FEED.

Mesh of Screen		Per Cent. of Weight	Assay Value Per Cent. of Copper	Per Cent. of Total Copper
On	Through			
100	—	20.49	1.88	10.8
120	100	8.05	2.02	4.6
150	120	3.55	1.71	1.7
200	150	12.92	2.64	9.3
—	200	53.92	4.85	73.3
—	Loss	1.07	—	—

The loss is almost entirely of the finest size. Note, over 50 per cent. passes through 200 mesh and carries over 70% of the total values.

Similarly the tails were screen sized and assayed. Small differences will be noticed in the percentage of sizes of feed and tails, due to the difficulty of making an exact separation. The difference is not enough to affect the conclusions drawn.

Again, note the high percentage of finest sort with high assay value, and that this same size carries over 90% of the total loss.

The following table gives the weights and values of the tails:

SLIME TABLE TAILS.

Mesh of Screen		Per Cent. of Total Weight	Assay Value Per Cent. of Copper	Per Cent. of Total Copper
On	Through			
100	—	19.5	0.25	2.1
120	100	8.29	0.28	1.0
150	120	3.78	0.28	0.5
200	150	11.08	0.54	2.6
—	200	55.74	3.80	93.7

Similar results were obtained on another slime table.

SLIME TABLE TAILS.

Mesh of Screen		Per Cent. of Total Weight	Assay Value Per Cent. Copper	Per Cent. of Total Copper
On	Through			
120	—	22.8	0.27	3.7
200	120	21.0	0.30	3.9
—	200	56.2	2.67	92.3

On both tables over 90% of the loss occurred in the finest sizes.

Between molecules exists a state of mutual attraction—a particular form of the universal force of gravitation[1]—of extremely small range.

The molecular attraction is sometimes said to be "insensible at sensible distances."[2]

Though limited in range this force is very powerful.

In the case of a water and air surface the sum of attractions on the water side of the surface is much larger than on the air side, where the molecules are much scarcer. The net result is the attraction of each molecule on the surface towards the interior of the liquid.

If the mass of water is sufficiently small it will take a globular shape. The result is exactly as if the outer layer of molecules were an elastic contractile skin. This effect is known as surface tension. The amount of the tension has been calculated by Sir W. Thompson as 75 dynes per lineal centimetre.[3] A good illustration of the immense force exerted by these surfaces is given by Tait.[4]

Two glass plates 6″ square are separated by a film of water 1/200″ thick. The meniscus of water around the edge of radius 1/400″ exerts a pull of between 6 and 7 lbs. in addition to the adhesion over the surface.

If a solid body instead of air is touching the water the number of molecules on each side of the surface of contact will be more nearly equal. If the attraction by the solid molecules is greater than the water surface tension the body will be wetted. Otherwise the solid will be "nonwettable."

Now, consider a solid particle immersed in water. Let it be unwettable. Allow it to come to the surface. The adhesion between solid and water is less than the surface tension of the surfaces, therefore the film of water will be torn from above the particle. The surface tension tends to pull the whole water surface into a spherical shape, hence the particle is ejected and supported by the outer film of water. A hollow will be formed in the water surface to produce hydrostatic equilibrium. The particle will float unless the weight is great enough to overcome the surface tension.

The maximum size of a particle that can float by greasy flotation depends on the surface tension of the water, the adhesion between water and solid, the length of circumference at the water line and the weight of the particle, or the more irregular and flakey and the more nonwettable, the larger the floating particle.

A wetted particle can never come to the surface. Adhesion

1 Sir W. Thompson. Constitution of Matter, p- 49.
2 Hawkesbury. Trans. Royal Society, Vol. XXVI, p. 1709.
3 Sir W. Thompson. Constitution of Matter, p. 49.
4 Tait. Properties of Matter, p. 247.

will always keep a film of water over it and render "greasy flotation" impossible.

Now, let the nonwettable particle grow smaller and be immersed. As the radius of curvature decreases the resultant of the surface tension towards the centre of the particle will increase. This resultant plus the attraction between the solid and liquid particles will at some point equal, and then exceed the surface tension of the liquid. The film of water surrounding the solid will be bound firmly to it, and the fine "nonwettable particles act as though wetted, and "greasy flotation for them ceases, consequently there is an inferior limit to the size of floating particles that can emerge. Measurements confirm this.

"Greasy flotation" particles were skimmed from the surface of the water of a table running on chalcopyrite ore. At the same time a portion of the water with its suspended particles was taken in another dish.

The particles were transferred to glass slides and measured with a micrometer microscope. In each field of view a number were actually measured, the size of the remainder estimated by comparison. The numbers of each size were counted. Many thousands of particles were thus measured.

Several days later the experiment was repeated with another lot of ore.

The results are shown on the accompanying curves.

The largest particles are not more than 1/3 of a millimeter. These were flaky triangular pieces. The lower limit appears to be in the neighborhood of .076 mm. Many of the finer particles were carried over with the water when collecting the floating particles and many others would be carried by adhering to the larger particles.

The maximum size of the suspended particles lies between .04 and .03 mm.

No method is known by which a comparison can be made between the sizes found and the theoretical sizes.

"Greasy flotation" has been employed to separate chalcopyrite from its ores. In the MacQuiston process the ground ore is repeatedly poured on the surface of a stream of water. The wettable quartz sinks, the nonwettable floating

The machine consists of four tubes 6'x1'-feet with helical 1½" pitch grooves inside. Tube revolves 3 revolutions per minute. No chemicals are used.[1] It should be remembered that particles too fine to come to the surface are too fine to sink through the surface tension film.

Now, let us consider a bed of wet grains. These grains, if only loosely packed, have a considerable amount of water between them. They easily move on one another. The heavy ores can go to the bottom, the lighter to the top.

If the bed be left undisturbed the particles settle closer

1 Selwyn-Brown. Engineering Mag., Sept. 1908, also Can. Min. Journal, p. 536.

together, the water between particles, if they are wettable, becomes reduced to a mere film, which adhering to each particle acts as a cement.

"Hillgaard regards the particles as irregular spheroids, each of which can contact at best at 3 points with other particles, the cause of aggregation therefore cannot be surface tension, independent of the liquid, and the particle being submerged, there is no meniscus to create adhesive tension. Since experiment shows that the flocculative tendency is measurably increased by the *cohesive coefficient* of the liquid, it seems necessary to assume that capillary films of the latter interpose between the solid surfaces and create adhesive tension."[1]

Why unwettable particles should form a solid bed is not so easily seen. The particles touch each other at points. The spaces between are filled with water. The surface tension drags at the films around the points of contact, attempting to assume a spherical shape of surface, and so pressing together and binding groups of particles more firmly than simple adhesion could. Hence a bed of nonwettable concentrates is solider than a bed of wettable feed.

The object of the vibratory motion on Vanners is to take advantage of this superior solidity of the concentrates and to loosen up the feed alone.

A particle of concentrates coming into contact with a layer of previously deposited concentrates is gripped and held. In this respect these tables have an advantage over jerking tables where no solid bed can form.

The tendency of nonwettable particles to stick to nonwettable particles under water has been advanced as the reason for the peculiar suitability of linoleum for table tops.

Linoleum is composed of grains of cork embedded in a matrix of oxidised linseed oil, of which one material is presumed to be more wettable than the other.

The film of water is anchored down by the wetted parts and bridges over the nonwettable to which the nonwettable grains would stick.

If a drop of water is allowed to run over the surface of linoleum the thin edge where the water was on the point of drying would present a jagged appearance if the above mentioned difference of adhesion was present, but only a smooth continuous edge was found, consequently it must be considered that the friction of the surface is the important thing.

Of all liquids except mercury, water has the greatest surface tension. The use of mercury is usually out of the queston because of its density and price.

If some means could be found to considerably raise the surface tension of water, concentration by "greasy flotation" could be applied to many more minerals and would become a most valuable process. Surface tension can be altered by the

1 Whiley Agric Analysis, Vol. III, p. 180.

addition of different substances, thus surface tension diminishes with increase of temperature[1], the addition of fusel oil reduces it enormously.

A bubble of air or any gas is nonwettable. Many metallic sulphide particles are nonwettable. If the air bubble touches the particle the water forms a meniscus around both, and the bubble sticks to the particle. If enough bubbles stick the grain will float. This is the basis of most flotation processes.

The plan was devised by C. V. Potter at Broken Hill, N. S. W. Acid acting on a carbonate produced bubbles. It was used on zinc-lead ores. It has been superceded by similar but more efficient processes.

Most minerals when exposed to the weather tarnish. The thin film of oxide alters the adhesion and the particle becomes wetted and the bubbles will not stick. To overcome this difficulty acid, usually crude sulphuric, at the rate of 10-20 lbs. per ton, is added to the pulp. It removes the tarnish. It may to some extent alter the surface tension. Common pyrite separates well with acid alone of less than 1% strength.

Other liquids have the property of wetting some bodies and not others. Among these is oil. It has great adhesiveness for some metallic sulphides, but for wetted surfaces none at all. Water will wet gangue minerals but not the metallic sulphides. If an ore is treated with water first and then mixed with oil, the sulphides become oily, the other particles wet. The difference of surface tensions on the gangue and sulphides is greatly increased. Bubbles, being nonwettable, now more readily attach themselves to the greasy particles.

To complete the operation several methods are employed.

The acid-oil process is as follows: Sands and slimes containing about 18% water are agitated with 10-15 lbs. H_2SO_4 and 1 lb. crude mineral oil per ton of 2240 lbs. The mixers are heated to 120° F. The mixed pulp is then sent through $5 \times 5 \times 5$ ft. V spitskasten and the concentrates floated off. A certain amount of calcite provides CO_2 bubbles which attach to the concentrates of zinc and lead sulphides. At Broken Hill the recovery averages 68% of the silver, 80% of lead, 75% of the zinc.[2]

The Krupp process employs heat to expand the bubbles and increase their carrying power. The mixer is a high, narrow cylindrical tank. The flow of concentrates over the top is regulated by the inflow of feed and the outflow of tailings at the bottom. A hot solution of 1% sulphuric acid is admitted through leaden pipes at the bottom.[3]

The Elmore oil process uses an excess of oil, which floats to the surface, carrying the sulphides with it. The oil and acid are mixed in a trough with wooden stirrers. It then passes to

1 Tait, Properties of Matter, p. 247.
2 Williams. Eng. & Min. Journal, 1908, p. 893.
3 Eng. Min. Journal, No. 86, 839-42.

separators where the oil and watery tailings separate. The oil is turned into a fast-revolving cylinder. The concentrates cake by centrifugal force on the outer wall of the drum. Excess of oil and water flow over the top.

The concentrates are removed at intervals.[1]

The Elmore vacuum process which is the most promising of the acid-oil processes, employs a vacuum to expand the air bubbles. Enough air is contained in ordinary water to supply the bubbles under diminished pressure.

Only enough oil is used to wet the sulphide particles—5 to 10 lbs per ton. Acid is added at the rate of 10 to 15 lbs per

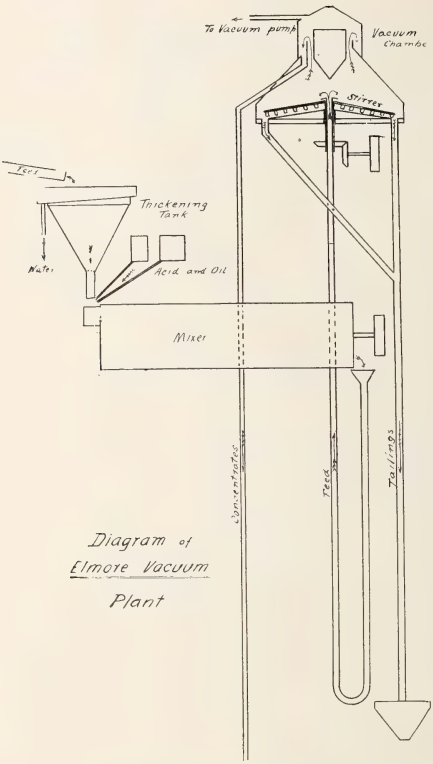


Diagram of Elmore Vacuum Plant

ton. The pulp is stirred in a mixer as in the Elmore oil process. From the mixer the pulp passes up one leg of a syphon and down the other. The upper end of the syphon is enlarged into a chamber several feet in diameter. A revolving stirrer assists the separation of the concentrates as the pulp passes over the floor of the chamber. A vacuum pump removes the air liberated and preserves the continuity of the syphon. The concentrates descend from the surface of the water by a third leg of

1 Eng. and Min. Jour. Vol. 74, p. 371, Vol. 75, pp. 262, 292.

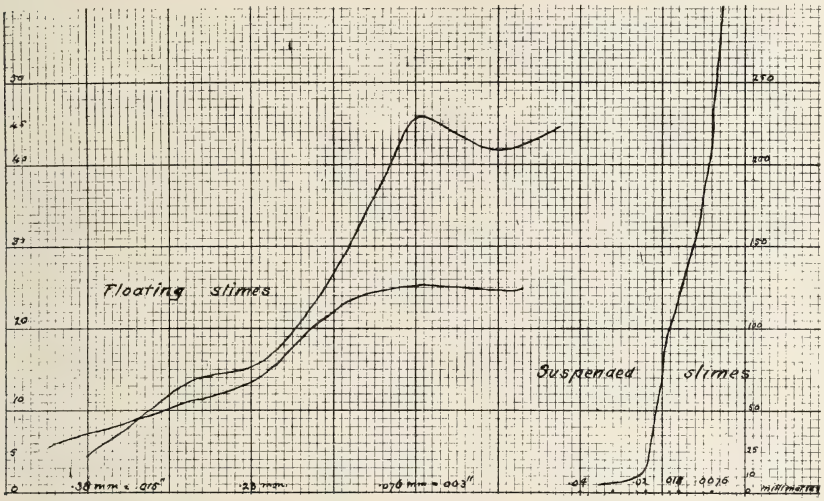
the syphon. The amount of oil used is too small to pay for saving.

This method has a high efficiency, extraction running from 80 to 97 per cent.[2]

Its low working costs render it suitable for low grade ores, having been brought as low as 60 cents per ton.[1]

Another process uses solid greases instead of oil. Crude vaseline is applied by means of a roller and a bath of melted grease to a canvas belt with a woollen face. The belt is set at a steep incline 45° or more and travels upward at a rapid rate two hundred feet or more a minute. The steeper the belt the greater the speed.

The sulphides stick to the grease as the pulp runs down the belt. The rich outer layer of grease is removed by a scraper



and falls into the bath of hot grease. The concentrates sink to the bottom, the grease being used over again. Excess of vaseline is removed by a centrifugal separator similar to Elmore's.

A small board 10 feet long, 1 ft. wide with 1" sides and properly stiffened, was used to make tests of this process. Vaseline was liberally smeared over the board. This grease table was set at a slope just sufficient to create a velocity of flow enough to carry quartz tailings along. Chalcopyrite and quartz ore was choke crushed with a Blake crusher. The over size on a 30 mesh screen was rejected. The remainder was mixed and sampled, 1 kilo was weighed out and thoroughly wetted with water. The slimes were poured into a separate can. The

1 Literature of Ore Concentration, etc., London.
2 Can. Min. Inst., 1908, p. 461.

coarse particles were poured over the table and repoured three times, each time being followed by a wash of water to clean off the last of the tailings. The surface was rubbed between each pouring to present a fresh surface of vaseline.

The fines were then treated similarly, being poured over the table 10 times.

Examination of the coarse showed it to contain grains of pyrite so large that the flow of water carried them off the board.

The fines still contained pyrite and so the operation was repeated 5 times more.

Area of board 10 sq. feet, therefore the coarse passed over 40 sq. ft. and the fines passed over 150 sq. ft. of grease.

The tailings were dried screen sized and assayed.

The vaseline was scraped from the board, melted on a water bath and the clear vaseline poured off.

From the concentrates the remainder of the grease was removed by gasoline and the concentrates assayed.

This table gives the results:

	Wt.	Assay Val.	Total copper.
Feed	1000 grms.	4.15%	41.5 grms.
Conc.	103.9 grms.	28.26	30.13 grms.
	6.3 grms.	19.4	

This gives an efficiency of 72.6 per cent. The tailings assay is in the following table:

TAILINGS.

Size of Screen		Weight in Grams	Assay Value	Total Amount Grams Copper	Per Cent. of Loss
On	Through				
40	—	186.51	2.18	4.06	36.0
60	40	314.40	1.41	4.44	39.3
80	60	87.73	0.54	0.48	4.3
100	80	73.70	0.36	0,27	2.4
120	100	30.71	0.41	0.13	1.1
150	120	21.36	0.55	0.11	1.0
200	150	71.05	0.69	0.49	4.3
—	200	102.31	1.28	1.31	11.6

These results show the chief losses to lie in the largest and smallest sizes.

A second experiment was tried with the same crushed ore that had lain exposed to the air of the laboratory for two weeks. The saving was extremely small owing to the oxidation of the surfaces of the copper pyrite.

A fresh portion was crushed as before, sifted through an 80 mesh screen to remove the coarsest grains. The efficiency was raised to 82.3%, most of the loss being in the fine sizes.

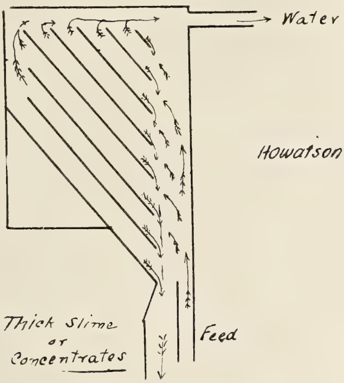
The losses in the fines is, partly at least, due to some of the grains acting as wetted particles.

Because of the similarity of the surface tension actions involved in this process and the Elmore vacuum process it is probable the sources of loss are the same in both.

The flocculative tendency of fine slimes is taken advantage of in the Howatson filter[1], the Durant filter and others. The floccules once formed stand considerable disturbance without breaking up. The finest pulp gives the solidest floccules.[2]

The plup travels upwards and diverges over sloping shelves. The decrease in velocity due to increased space allows the slimes to settle on the shelves. The short distance they have to fall shortens the time required. The agglomerated slimes slide off the shelves and fall through the ascending currents without breaking up.

Other factors beside the density of pulp enter into the settling of slimes. The density and viscosity as they increase



reduce the settling rate, though Dr. Barus states the viscosity had no effect on some fine particles in his experiments [3] with regard to the velocity of fall.

Slimes settle notably fast in distilled or hot water, results due no doubt to the reduced sp. gravity of the medium[4]. Others consider the changes too great to be laid to the charge of sp. gravity[5].

By others the retardation is laid to occluded air and small bubbles [6] but in most cases the effect of air is small[7].

Increase of temperature decreases the flocculative tendency[8].

Ordinary temperature changes are sufficient through convection currents to overbalance the extremely slow falling rate

1 Inst. Min. & Met., Vol. 17, p. 311.
2 Whiley. Agric, Analysis, Vol. 1, p. 180.
3 Richards Ore Dressing, p. 474.
4 Nichols. Inst. Min. & Met., Vol. 17, p. 295.
5 Sulman. Inst. Min. & Met., Vol. 17, p. 312.
6 Richard's Stamp Milling of Gold Ores, p. 126.
7 Nichols. Inst. Min. & Met., Vol. 17, p. 320.
8 Whiley. Agric. Analysis, Vol. I, p. 181.
9 Ibid.

of the finest particles[9] but experiment proves that particles protected from temperature changes settle very slowly, and that particles held in suspension for weeks are still of measurable size, that is greater than .0001 mm.[1]

Sulman as a result of "measuring the angle of contact between liquids and solids found a rise of temperature modified these angles quite out of proportion to the slight change in density due to heat. He considers, therefore, that heat is a factor producing results inexplicable by change in density alone.[2]

There are two explantions of the slow settling of slimes and both are probably true, i. e., the electrostatic theory and the colloidal theory.

The electrostatic theory is as follows: The molecules of water and the particles of solid become electrified, the solids usually becoming negative and the water charged with positive electricity.

The solid particles being charged alike, repel each other and consequently become diffused through the liquid. This probably explains the increase of settling rate due to removing the bottom slimes.

If an electrolyte be added to the water its molecules become ionized into +ve and —ve ions, which neutralize the —ve and +ve charges on the solids and water, destroying the electrostatic repulsion of the solids. It follows that an increasing quantity of electrolyte will neutralize the charges on an increasing number of particles until the whole are neutralized. This is the point of maximum efficiency. If the number of electrolyte ions is further increased the particles become reelectrified and the action is reversed.

The efficiency of electrolytes to settle particles varies greatly with the nature of the suspended substance.

For metallic sulphides 1 part of common salt to 60 water is only as efficient as 1 to 200 for calcium chloride and for iron, ammonia alum, 1 pt. in 90.000 of water. Thus iron am. alum is more than 1,000 times as efficient as salt.

An excellent description of this theory and experiments in connection with it is in Perrin Journal de Chemie Physique Vol. 2 and 3, and Neues Jahr Buch fur Mineralogie, 1893.

An idea of the great difference in rate of settling may be gathered from this table[3]. The ore was Nova Scotia gold quartz.

Electrolyte	O added	Na.	Cl.	Am.	Alum	HCl.	H_2SO_4
Per cent. added	0	½	1	½	1	.19	.15
Per cent. settled	22	89	99	97	100	100	100
Time in hours	½	½	½	½	3	½	½

The addition of electrolyte caused the previously invisible

1 Whiley. Agric. Analysis, Vol. I, p. 181.
2 Inst. Min. & Met. Vol. 17, p. 312.
3 Richards Ore Dressing, p. 1147.

particles to agglomerate immediately into visible grains[1]. Nichols states that in the very thin pulps the temperature may be more potent than electrolytes.

In thicker pulps any cause counteracting the repulsion due to electrostatic condition would be more and more potent as the particles crowd together.

In pulps containing more than 15% of solids the effect of electrolytes and change of temperature becomes rapidly obscured[2].

Mill tests were made to test the possibility of utilizing the increased settling rate in the treatment of chalcopyrite on slime tables.

In the first experiments the ore was mixed, divided into three lots. One part was used to adjust the table, the third part mixed with salt at the rate of 2 lbs. to the ton of 2,000 lbs. The second part was left unsalted. The ore was crushed in a stamp mill, the slimes separated by a classifier and sent to a slime table. Samples of the feed and unsalted tails were taken. The salted portion was then worked over and samples taken as before. A decided gain was found.

In a second experiment the ore was crushed under stamps through an 80 mesh screen and sent direct to the tables. The pulp thus contained a large portion of fine sands.

The pulp was divided by a partition in the launder into two equal portions, one of which went to slime table No. 1 and the other to slime table No. 2.

A pail of strong salt water was set on the launder and arranged to deliver a stream of salty water into either half of the divided pulp.

The salt was first added to the No. 2 table feed, and samples taken from both tables.

The salt was then switched to No. 1 table feed and samples taken. No other changes were made.

By running both tables possible variations due to feed, change of temp, inequalities of salt supply, were eliminated.

	Assay value	Diff. in %	Efficiency
Feed	3.94 % cu.		
No. 1 table, tailings, not salted	1.59		59.6
No. 1 table, tailings, salted	1.53	.06	61.2
No. 2 table, tailings, not salted	2.17		45.0
No. 2 table, tailings, salted	2.07	.10	47.5

On each table the salt raised the efficiency. Salt was used because of its lesser corrosiveness than acid, and also for the ease of obtaining it. Other electrolytes might have given an even better result.

1 Richards. Ore Dressing, p. 1149.
Inst. Mining and Met., Vol. 17, p. 238.

A CIRCLE DIAGRAM FOR THE ALTERNATING CURRENT SERIES MOTOR

It is an established fact that complete and accurate characteristics of an induction motor can be obtained by means of the "circle diagram" of Heyland and others. Taking this diagram

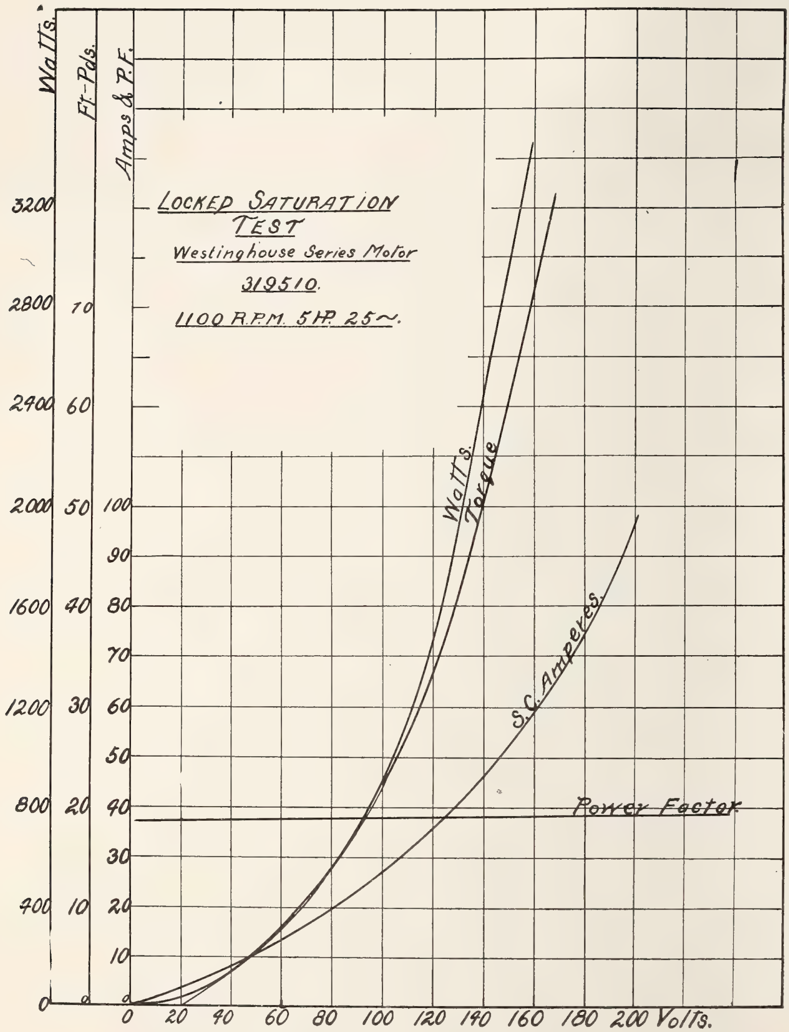


Fig. I.

as a basis, the performance and other properties of the single phase series motor may be approximately pre-determined.

Construction of Diagram.

To obtain data necessary to construct the diagram, two

tests, a "locked saturation" test and a "no load" test are required. For the locked saturation test the motor armature is clamped and reduced voltages are applied. Readings are taken of volts, amperes, watts and torque, care being exercised that the frequency is kept constant at rated value. Plot curves of watts,

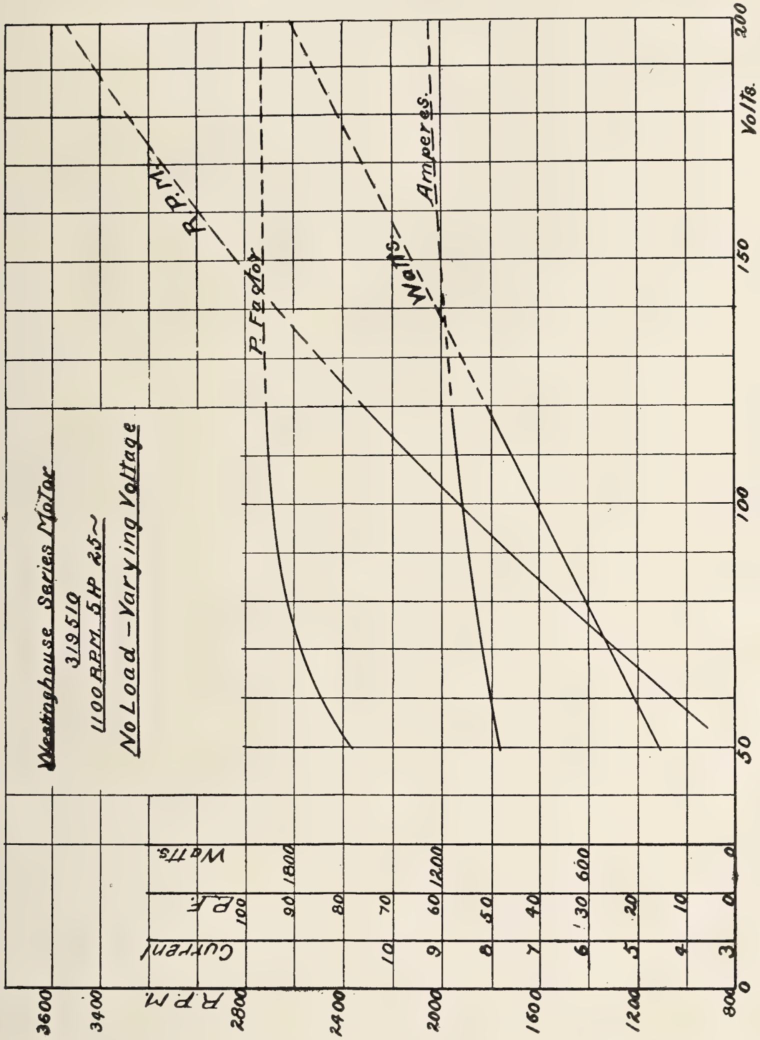


Fig. II.

amperes, torque, and power factor on voltage base and interpolate from the values for results at required voltage. (See Fig. 1.)

For the no load test the machine is run light at reduced voltages up to that pressure causing maximum allowable speed. Readings are taken of voltage, amperes, watts and speed. Observations are again plotted (Fig. 2) on a voltage base and

interpolations made for data as in the locked saturation test.

To construct the diagram, proceed as in the case of the "induction motor." Assume the horizontal line *OX*, (Fig. 3,) to represent the direction of the current at zero power factor, and *OY* the vertical will be the direction of the *E.M.F.*

From the locked saturation test (Fig. 1) plot to scale the current vector *OP* in proper phase relation with the impressed voltage, the power factor being then represented by the cosine

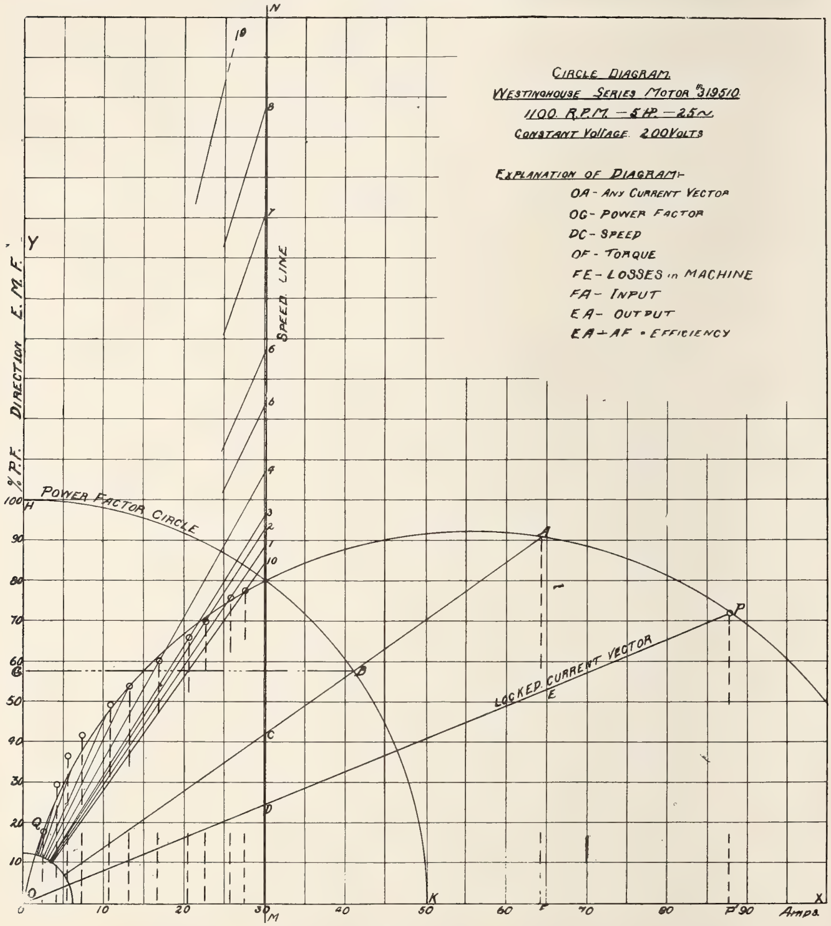


Fig. III

of the angle *YOP*. Similarly from the no load test (Fig. 2) plot to scale the current vector *OQ* in proper phase relation, cosine the angle *YOQ* being the power factor, care being taken that both current vectors are taken at the standard voltage and frequency. Through the points *OQP* describe a semicircle, the locus of the current vectors. Centre *O* draw arc of a circle *HBK* also any line *MN* perpendicular to *OX*.

The quantities represented in the diagram can best be shown by a definite example.

METHOD OF USING DIAGRAM.

OA is any current vector at power factor represented by cosine angle *YOA*. This may be read directly as % by length *OG*, where the length *OH* is 100 % power factor. Distances along line *MN* represent to scale the speed of the armature The intersection of this vertical line *MN* and the locked current vector *OP* is zero speed. The vector *OQ* intersects line *MN* at 9. The distance *D*.9. represents the speed of machine at no load, therefore *D.C.* is speed under conditions existing when *OA* is the current vector.

The torque obtained in the locked saturation test will be represented by the length OP^1, *OF* therefore represents the torque under assumed conditions. PP^1 is the energy component of the locked current and also represents the input and in this instance the losses in the machine. For the assumed conditions *FA* is the total input to the machine *FE* the losses, consequently *EA* will be the output, and finally $EA \div FA$ the efficiency.

RESULTS.

In the following table, comparisons are given of the results of an actual brake test and the results obtained from the method indicated in the diagram. The performance curves from both methods are shown in Fig. IV.

LOCKED SATURATION TEST.

Volts	Watts	Amps.	R P.M.	Torque	Power Factor
200	7220	95	0	103.8	38%

NO LOAD SPEED TEST.

Volts	Watts	Amps.	R.P.M.	Torque	Power Factor
200	1792	9.25	3520	0	97 %

BRAKE TEST RESULTS.

Volts	Input Watts	Amps.	R.P.M.	Torque	Power Factor	Output Watts	Effcy
200	7805	47.8	723	50	81.65 %	5135	65.7
	7620	46.0	820	46	82.75	5358	70.3
	7010	41.7	880	40	84.1	4999	71.3
	6625	39.0	930	36	84.9	4758	71.8
	6032	34.5	1030	30	87.35	4387	72.8
	5400	30.0	1180	24	90	4025	74.5
	4940	27.0	1280	20	91.45	3637	73.6
	3650	19.1	1800	10	95.6	2555	70.0
	2942	15.3	2220	6	96.2	1891	64.2

CALCULATED RESULTS FROM DIAGRAM.

Volts	Input Watts	Amps.	R.P.M.	Torque	Power Factor	Outpup Watts	Effcy
200	2845	15	1900	8.3	95.0%	2240	78.5
	3740	20	1652	12.6	93.5	2960	79.0
	4600	25	1418	17.3	92.0	3480	75.5
	5400	30	1232	23.3	90.0	4070	75.4
	6120	35	1048	30.4	87.25	4520	73.7
	6840	40	913	37.0	85.5	4800	70.2
	7450	45	788	44.8	82.75	5020	67.3
	8000	50	684	53.3	80.00	5200	64.8

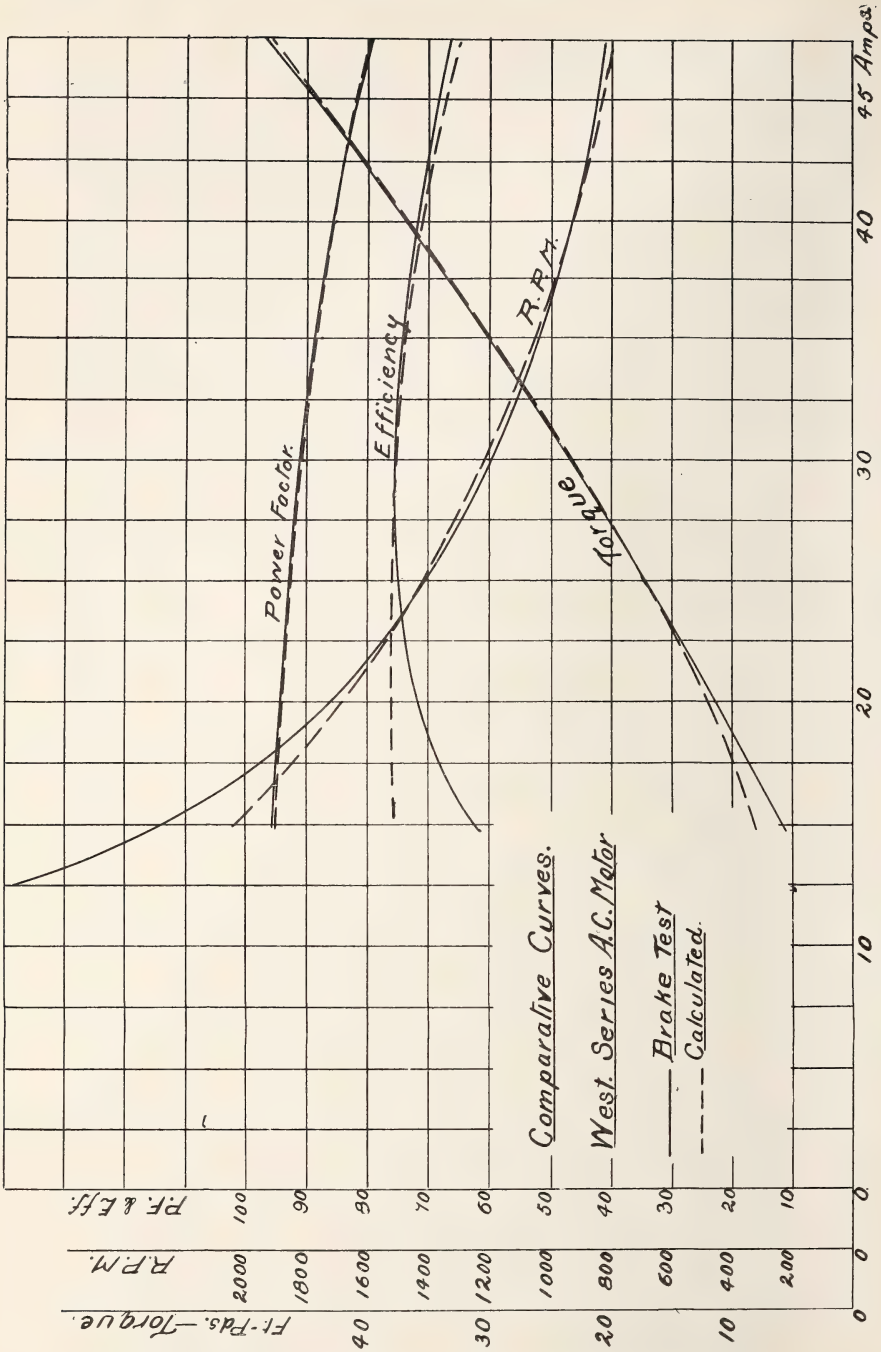


Fig. IV.

NOTE—"Applied Science" desires to express its appreciation for this article to Messrs. Fierheller, Hopkins and Dundass of the Electrical Engineering Staff.—ED.

PURE WATER BY MEANS OF ELECTRIC-OZONE.

R. H. Hopkins, B.A.Sc.

The following article is a brief description of a modern method of purifying water by means of electrically produced ozone.

The plant, which is the first municipal ozonizing one in America to treat the entire water supply of a community has just been installed at Lindsay, some seventy miles north east of Toronto. The town is in the centre of a rich farming district. It takes its water supply from the Scugog river, a sluggish, muddy, weedy stream, which in turn receives its supply, some twelve miles up, from Scugog Lake, on which is located the village of Port Perry, which runs its sewage into the lake.

The town receives its water from mains at a pressure of 60 to 120 lbs. this pressure being maintained by means of a standpipe on a hill at the west of the town, to which the water is pumped from the pump house on the banks of the river just above the town. The filtration system in use prior to the installation of the ozone purification plant consisted of a twelve-inch pipe leading from a crib sunk in the river to a rough filter containing some 18 inches of sand, gravel and charcoal and thence to the pure water tank, from which the water was pumped into the mains. The inefficiency of this method was such that the water had a murky, muddy color, a disagreeable odor and bad taste; besides which the germicidal properties of this filter as shown by tests were practically nil.

In april, 1908, the water commissioners made an agreement with Mr. James Howard Budge of Philadelphia, the inventor of the system, to instal on trial an ozone purification plant. The contract took effect September first; and in the remarkably short time of eight weeks the town received ozonized water. This time would have been considerably shortened but for the unlucky fact that an almost impenetrable blue clay was encountered in excavating for the water and ozone mixer.

This is not the first time that ozone has been used in the purification of water but hitherto the cost has been excessive as shown by the following extract from the report of Mr. I. M. de Verona, M. Am. Soc. C. E. chief engineer of the Department of Water Supply of the city of New York, on a series of tests made by the officials of that city of an ozonizing plant in 1907.

"'The experiments showed that of the amount of K. W. energy used, about one quarter was consumed by the refrigerating machine, one quarter by the transformer and ozonizer, and one half by the compressor. It appeared that the color might be reduced from about 15 to 5, and bacteria from 100 to 7, by the use of about 3,500 grms of ozone per 1,000,000 gals. with an expenditure of about 800 K. W. hr. electrical energy, 200 of which were expended in the ozonizer and transformer.

With electrical energy costing 2½ cents per K. W. hr. (a low price) it appears that under the conditions of the experiments the process was costing about $20 per 1,000,000 gals., of which perhaps $5 represented the cost of the ozone and the other $15 were chargeable to drying the air and pumping it into the water."

This plant did not run a single day without stopping, but these stops with a single exception were all due to defective working of either the refrigerator or air compressor. The one shut-down due to the ozonizer was caused by a preventible short circuit. The stop was only momentary, however, an extra unit being instantly switched in.

The cost for power here, although stated as low, is excessive (especially as this use for electricity is an all day one, which can be stopped for a few hours at peak loads and there-

Plant Under Construction, Lindsay, Ont.

fore should get special rates), as the following figures will show:

2½ c. a K.W. hr. = $56 H.P. year, 10 hr. day, 300-day yr.

2½ c. a K.W. hr. = $163.80 H.P. year 24 hr. day, 365-day yr.

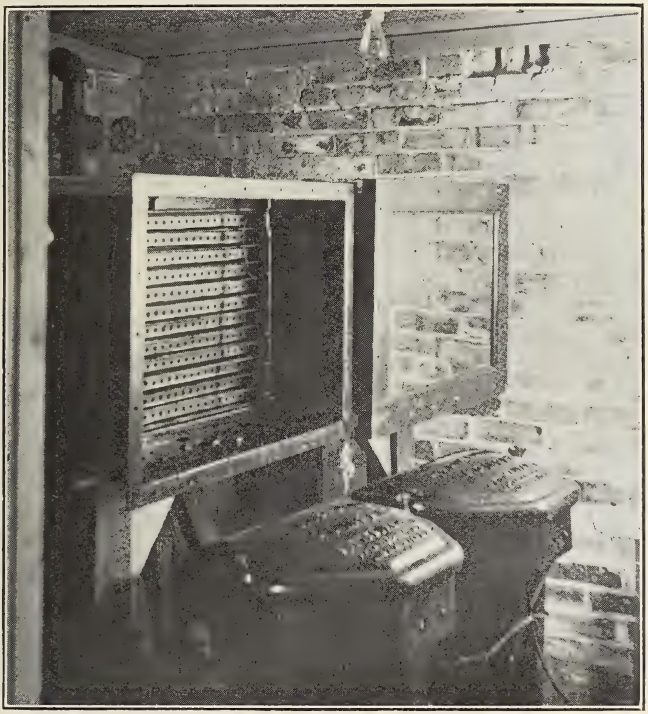
Power is supplied in Orillia at $16 H.P. year, 24 hr. day, 365 day year; in Niagara, $12 to $25 a H.P. year; in Lindsay, $25 to $35; and it is expected the rate will be $18.20 per H.P. year in Toronto.

A reasonable cost for 24 hour a day power in New York for this style of service would be 1c. a K.W. hour (it can be produced for less than this there). This would bring the cost of the imperfect system there tested to $8.00 per million gallons. In Lindsay it is 77c. per million, which sum with interest and depreciation on the plant is brought up to $2.75 per million. Slow sand filters cost from $7 to $9 per million gallons and mechanical filters cost $10 to $12.50 per million gallons. The results of the New York test, as stated, were not the best obtain-

able, owing to the ozone used being insufficient. In Europe the standard is 3785 grms. of ozone per million gallons of water. Here are some of the results obtained at the de Fries plant near Paris, by the official authorities of that city:

Grms. of ozone per cubic meter of water.	Bacteria before ozonization.	after ozonization.
2.216	800	2
2.035	850	3-4
1.352	2682	3

The Lindsay plant consists of a raw water basin Hungerford sand filter, Asperator sterilizer, ozonizer and pure water

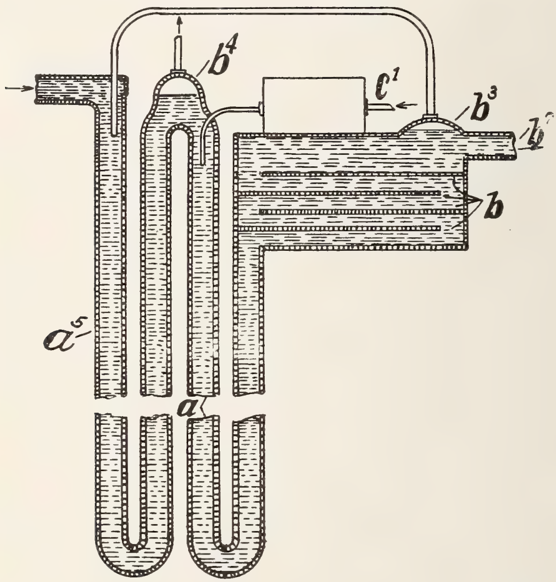


Views of Ozonizer

basin. The filtered water basin of the old plant is utilized, the water passing from these through an 8″ pipe into the surface of the sand in the Hungerford filter, losing about 2″ of head in so doing. This rough mechanical filter is intended to strain out the suspended matter. The suspended matter is excluded for two reasons, first a question of color, as suspended particles always give water a muddy color which can only be removed

by a filter, as ozone has little or no action on suspended matter other than organic matter and bacteria; second a saving of ozone, as organic matter may to some extent be removed by a filter, and therefore the ozone will only have to act on the bacteria and the dissolved organic matter that passes through the filter.

The rough filter consists of a rectangular tank of reinforced concrete 12 by 15 feet deep sunk in the ground. It contains a series of pipes which gradually enlarge as they join each other, finally terminating in an 8″ discharge pipe. Sunk in the upper sides of these pipes are 130 brass sand valves, which allow the water to pass in either direction but exclude the sand. On these valves there is about three feet of sharp hard sand which accomplishes the removal of the grosser particles



Raw water enters the pipe a^5 drawing, by suction, unobsorbed ozone from b^3 The waste gases escape at b^4. The current of water in a sucks fresh ozone into itself from the ozonizer c; and after passing around the baffle plates in b, the purified water escapes at b^2.

of suspended matter. The filter is cleaned by means of a valve so arranged that water from the city mains at a pressure of 60 to 90 lbs. can be passed upward through the valves and sand. The wash water escapes through two valves into the river. This process of washing takes about three minutes and is done every second or third day, depending on the condition of the river.

In flowing through the Hungerford filter the loss in head

at 500 gallons a minute is 4′ 8″. It was designed to work at 1000 gallons a minute, but the level of the river during this very dry season has fallen lower than ever before and there is not at present sufficient head to give this large volume of water. Under ordinary circumstances 500 gallons per minute is the pumping rate. This rate, however, is doubled during fires; an auxilliary filter of the same type may be installed to give 1000 gallons a minute at any level of the river.

From the rough filter the water passes into another chamber in which its height is regulated by a butterfly valve and float. Here it flows into an air-tight box of concrete connected to the ozonizer by a 2″ pipe. The water now falls through a number of four-inch pipes, leading to the bottom of a well 30 feet deep, passing in so doing the ends of a great number of small pipes (see diagram for theory). The water by suction thus draws the ozonized air into it; and here is one of the special features of the plant. Other ozonizing plants have used an air compressor to force the ozonized air into the water; and as the compressor has to be worked without lubricants which would otherwise be oxidized by the ozone, such a compressor is a very costly and unsatisfactory machine.

The water and ozonized air now pass slowly upward through a system of baffle plates (see diagram) which prevent the ozonized air from too rapidly leaving the water. The head required to operate this sterilizer when treating 1075 gallons of water a minute is only 20″. If the cost of power and consequently of ozone is high, the partially used ozone after passing from the water, may be collected and used over again. (See diagram.)

The electrical equipment is housed in a small brick "lean-to," 8 by 10 feet, built against the power house. In this building are two 2½ K.W. 60 cycle transformers, transforming from 1040 volts, the town distribution voltage, to 8,000, 10,000 or 12,000 volts, depending on the leads used; a ⅛-h.p. motor driving a small blower to supply air to the ozonizers; and the two ozonizers. t will be noticed that there is no drying apparatus such as is used in European practice, Mr. Bridge having found that the yield of ozone is not increased enough by this to make up for the cost of operating either a refrigerating machine or a mechanical dryer.

The ozonizers (see photo), of which there are two, are quite distinct, in fact each ozonizer, with its own transformer and separate air inlet and outlet, is a separate unit, so that either or both may be operated. Each ozonizer contains 26 electrodes, 13 negative and 13 positive, each protected by its iron fuse. The electrodes are plates of aluminium 20 by 34 inches, and are filled with holes similar to those in a nutmeg grater. By an arrangement of baffles, the insulation being micanite plates and fibre, each little discharge, of which there are five million, encloses a jet of air; and here is one of the fine points of the

ozonizers. It is a well known fact that an electrical discharge repels air, and if it were not for the arrangement in the ozonizers the air blown on the discharge would be repelled by it, and not nearly as large a percentage of ozone generated.

The plant as it is at present operated is supplying 4,000,000 to 4,500,000 gallons of water a day. Five hundred gallons a minute are pumped and about 4 h.p. of electricity is regularly used in the ozonizer. This may be increased to 8 h.p. as specified in the contract. The plant is costing the town $7,250; but this cost is low on account of using old filters and excavations. To duplicate it would cost in the neighborhood of $25,000.

The plant to date seems eminently satisfactory, the water after filtration is clear, cold, odorless and in fact looks and tastes like good spring water.

The following is the report of a preliminary report:

BACTERIOLOGICAL REPORT

March 22, 1909.

Report of water receied from Wm. Hammond, Water Commissioner, of Lindsay, on the 18th day of March, 1909.

We have received the following report of analysis of water from this plant. It speaks for itself:

Laboratory No.	Sender No.	Where collected from	Number of Bacteria using N. Agar + 10.0 at 18°–22°	Number of Bacteria using N. Agar + 10.0 at 37°–40°	Strepto cocci	Staphylococci	Colon Bacilli	*Colonoid Bacilli	Chlorine in parts per million
1299	No. 1	Rain Water	3800	—	—	—	—	—	2
1300	No 2	After Ozonizing	2200	—	—	—	—	—	2

+ = present.
— = absent.

Colonoid bacilli are such as belong to colon group. Bacterial counts are made only when specimens are still in ice and the "time limit" of ten hours has not been run over.

Remarks: The count speaks for itself.

John A. Amyot.
Prov. Analyst.

THE YOUNG CIVIL ENGINEER.

Close of Discussion by E. W. Stern.

To the gentlemen who have so ably and freely entered into the discussion, I wish to acknowledge my thanks and appreciation. They have given us the benefit of their valuable experience and earnest thought; not to mention their time. They have brought to it an intimate and sympathetic understanding of the young graduate engineer's position, as all are college bred men, and have risen from the bottom to the topmost ranks of their profession by sheer ability.

It is my good fortune to know practically all of these gentlemen, and to respect them, not only for their professional ability, but as men. Their ethical standards are of the very highest. They are all leaders in the full sense of the word and are highly appreciated by the community at large. What they have said, therefore, the result of mature thought, and actual experience both as employe and employer, along the very lines which go to make their remarks so very valuable to this discussion, can only be commended by me to your most thorough and serious consideration.

I have only one exception to make. In Mr. Thomson's discussion he states that it is nearly always desirable to obtain the largest salary possible on the principle that the employer is going to give the best work to the highest paid man.

I do not agree with Mr. Thomson in this, nor do other gentlemen who have discussed this paper. My own experience both as employe and employer is that this is not good advice. No better way to become a "floater" could be suggested. Often, when business is brisk and there is a scarcity of well qualified draughtsmen or assistants, a man may demand and obtain a higher salary than he is worth. His position is almost always temporary, for as soon as it is possible to reduce the force, he is among the first to be let go. Furthermore, an employer (if he is a sensible one) will give the best work to the man who is best qualified to do it, regardless of salary.

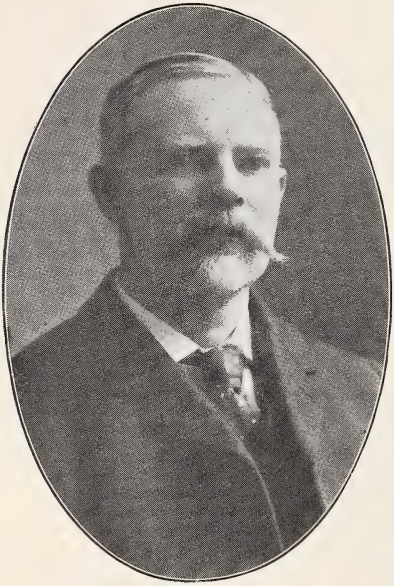
I have not intended to give advice to old engineers but only to the young graduate for the first few years of his career—in his practical post graduate work, so to say—the idea being that the young skipper sailing his craft in new waters, might be benefitted by the experience of the old mariners, as to just what shoals to avoid. He must soon sail his own craft, however, and steer himself.

The time will come when he will be able to master new situations and problems which present themselves, with tact and skill and the confidence born from experience. He will have found himself.

IN MEMORIAM.

James McDougall, B.A., Assoc. M. Inst. C. E.

James McDougall was born at Baltimore, Ont., in 1853. He was educated at Upper Canada College and University College, Toronto, and obtained his B. A. degree in 1880. Having decided upon civil engineering as his future profession, he entered the School of Practical Science, Toronto, in 1881 and graduated in 1884. Subsequently he taught for a short time as a private tutor. He began his professional work under the late Mr. J. T. Stokes, C. E., engineer for the County of York, and was employed on the Welland Canal and on the Canadian Pacific Railway under the late W. T. Jennings, C.E.



Jas. McDougall, B.A.

In 1892, on the death of Mr. Stokes, he was appointed engineer of the County of York, which position he held until his death on 2nd Sept., 1908. He was admitted to the Institute of Civil Engineers, London, England, as an Associate Member in 1906.

In addition to his duties as county engineer he carried on a private practice as a consulting engineer. He was the engineer in charge of the York Radial Railway system and its various extensions—was employed on such questions as the taking over of electric railways by municipalities—was an authority on concrete and reinforced concrete construction, etc., etc. His work was of the best. His ability, tact, good judgment and simple honesty gained for him the respect and confidence of all who came in contact with him in a business way. He combined in a marked degree theoretical knowledge with practical sagacity, kept closely in touch with the latest engineering developments, subscribing for both English and French engineering periodicals. One of his marked personal characteristics was his extreme modesty and dislike for publicity. He never pushed himself nor aided his friends in pushing him. By nature a student, he had the student's fondness for books and was an omniverous reader. I have been told by one of his former class mates in University College, who knew him intimately in after life that he was one of the best liberally-educated men the University ever produced.

While making no pretensions as a critic in literature and art, his tastes were cultivated and his judgment excellent. Among people with whom he felt free he was a delightful talker and a charming companion. He combined in a rare measure strength of intellect with delicacy of perception and refinement of thought. A keen sense of humor served as a shield to his too sensitive nature and saved him from many a trouble. Kindly and generous in disposition he had many friends but few intimate companions.

His memory will long be cherished by those who knew him best.

J. Galbraith

Duncan Sinclair.

Duncan Sinclair was born on Dec. 6th, 1870. He spent his boyhood days on his father's farm at Cheltenham, Ont., and secured his early educational training in the public school of his native village. Later, he attended Georgetown High School, where he secured his senior Matriculation. Following this he taught school for three years. In the fall of '99 he entered the School of Practical Science, obtaining his degree in 1903, and having been president of the Engineering Society during his final year. He first secured employment with the Hamilton Bridge Works, and subsequently with the Canada Foundry and the Grand Trunk Railway at Stratford. In the spring of 1905, he went to New Liskeard, where he became junior partner in the firm of Blair and Sinclair. In 1906 this was changed to Blair, Sinclair and Smith and in 1908 to Sinclair, Sutcliffe and Neelands.

Of the class of 1902, none was more highly esteemed than Duncan Sinclair. His native ability and industry placed him always well up in the lists and his unfailing cheerfulness won for him many friends. In later years when he rubbed up against the world in a community and an environment where opportunities to leave the path of strict rectitude were frequent and tempting, Sinclair always carried himself with the strictest honesty. He played the game fair and his word was as good as his bond. His illness dated from July, 1908, and although the best medical advice was obtained, permanent relief was not to be had, and he passed away on January 5, 1909, at his old home in Cheltenham. He is survived by his widow, formerly Miss Mary Stewart, of Parkhill, Ont., to whom he had been married only a few months previously. His untimely death has taken one whose capacity for work, whose business ability, whose integrity and whose geniality gave promise of a life of great usefulness.

Garnett Rae Jardine.

Garnett Rae Jardine was born near Bowmanville on Nov. 2, 1888. His early school days were spent there, and in Western Manitoba. He entered high school in Brandon, but returned, when 17, to Bowmanville, where he claimed honors, and in his final year tied with a comrade for first position.

Garnett Rae Jardine

While there, he decided to attend the School of Science and enrolled in the fall of 1906. At the close of his freshman year, honors again fell to him, which was only natural, since he seemed happiest in the pursuit of his studies.

Much of his second year was spent in chemical research and laboratory work. While thus engaged he unfortunately inhaled a quantity of nitrogen peroxide gas, which later irritated his lungs to a very great extent. His studies, however, did not suffer lack of attention until scarlet fever confined him to his bed, and, on March 5, 1908—less than a week from his last attendance at lectures—his death was reported among his fellow students. Then it was felt that one of the keenest of intellects and noblest of natures had "crossed into that undiscovered country from whose bourne no traveller returns."

When the present shall have crystallized into the past he will be remembered for his extraordinary ability, good fellowship, and genial disposition. When we think of his exemplary habits, moral character and devotion to high ideals, it helps us to better understand that

"Death's but a path that must be trod,
If man would ever pass to God."

W. F. Ratz.

The late W. F. Ratz, D.L.S., whose death through typhoid fever occurred at Ottawa on the 6th February, 1909, was a grad-

uate of the School of Practical Science of the class of 1902.

Mr. Ratz entered the "school" at the early age of sixteen. In spite of his youthfulness he acquitted himself most brilliantly throughout his entire course, graduating with honors and obtaining the T. Kennard Thomson prize in the Department of Civil Engineering.

Immediately after leaving the University he received an appointment in the Topographical Survey Branch, Department of the Interior, Ottawa, where he remained till the spring of 1905, when he was transferred to the Boundary Survey staff, under the charge of W. F. King, Chief Astronomer. It was at this time Mr. Ratz obtained his Dominion Land Surveyor's certificate, heading the examination lists.

His work on the boundary survey was in Southeastern Alaska. In the year 1907 he was engaged on the Stickine River, and in 1908 on the Endicott River.

His work was always carried on with the greatest accuracy. The service has lost a splendid surveyor, and the country a most promising citizen in the death of Mr. Ratz.

Among those who knew him, Mr. Ratz was a universal favorite, and none regret his untimely death, in his twenty-fifth year, more sincerely than do his fellow graduates of the University of Toronto.

PRESIDENT'S VALEDICTORY.

Gentlemen:—I have now come to my last duty as President of the Engineering Society. It is with a feeling of relief that I lay down the responsibilities, and with a feeling of regret that I must sever my connection with a work in which I have been intensely interested and into which I have thrown all my energies. I want to thank your for your co-operation during this past year. I feel that I can truly say, in every enterprise we have undertaken as an executive, we have felt at all times that you have not only approved of our course, but that you were willing to assist us in every way in making the business in hand a success. Much of what has been accomplished this last year can be attributed to your own energies administered at the critical times.

In reviewing the work of the year there are certain features of it which require more than a passing note.

The Supply Department has been reorganized to place it on a sound business basis with business principles as the root of the system. By a new method of keeping an account of the sales and checking stock it is believed we have placed in the hands of the auditors a means of checking the money handled in this branch of our work.

Arrangements have been under way for some time to secure for the Society the sale of text books in our supply department,

and I have good grounds for saying that this will in all probability be consummated before the new executive takes over the work. By this means we hope to add another source of revenue to the Society, and also to make it entirely independent of outside assistance. It is thought that, with these improvements, a clerk of supplies could be obtained at a reasonable salary, whose only duty would be to look after the sale of supplies, and this department could then be kept open at all hours of the day.

The present arrangement has been more or less critized, but it seems to me, the chief reason to be urged against it is that it interferes too much with the academic work of the assistant of the paid secretary.

It is hoped also that the revenue derived from this increased business will provide for a larger and better "Applied Science." Throughout this past year it has been our endeavor to keep "Applied Science" up to the standard, and if possible to put it upon a paying financial basis. This journal is one of the most important departments of our work, for through this medium we are kept in constant touch with the graduate body. I think I am safe in saying that "Applied Science" is going to accomplish all that its originators had in view at its inception.

Printed notes of lectures, which have been advocated so frequently in election platforms of recent years, are being obtained, slowly it is true, but nevertheless surely, and no doubt in a few years, will be in use in all departments.

In the Mechanical and Electrical section of the Society a new experiment was tried this year. Excursions were arranged to visit the different manufacturing establishments in and around Toronto and the experiment has proved very successful due partly to the energies of the Vice-President of that section and partly to the assistance given by the Faculty. These excursions could be extended to the other sections and would, in all probability, achieve the same results.

Our sectional meetings have been attended by a fair measure of success. The Vice-Presidents of the different sections have worked hard in their endeavor to make these meetings interesting and instructive, and they deserve credit for their untiring efforts. One feature which has been noticeable by its absence has been discussions on the papers presented; but the incoming Vice-Presidents should overcome this, benefiting by the experience gained by their predecessors. It was thought that the prizes offered in each of the sections at the beginning of the year would have the effect of increasing the number of papers and increasing the interest taken in their presentation. Unfortunately this plan has not had the desired effect this year.

A few alterations have been made in the constitution to suit prevailing conditions. These changes were made necessary by the course of events during our year of office, and we trust that these alterations have made it easier for our successors to

effectively and efficiently carry on the business of the Society.

One of these alterations has to do with the elections. This I want to explain. It was found necessary this year to hold the elections partly in the afternoon and partly in the evening, because of the increase in membership, and the University regulation requiring all university buildings to be closed at twelve o'clock. For the future the plan which commends itself, is to have all the voting during the day and then to have a "stag night" at the gymnasium.

The annual excursion, this year, to Buffalo was one of the most successful of its kind in the history of the Society. Over three hundred of the members enjoyed the trip.

The annual dinner, held in Convocation Hall on Jan. 28th of this year, was of more than ordinary importance. It marked the beginning of a closer relationship between the graduates and undergraduates and it also demonstrated to the graduates and our guests the important place the Faculty of Applied Sciences is destined to fill in the engineering world. To the undergraduate it proved that to be a graduate meant to be interested in the wellfare of the Faculty of Applied Science and the Engineering Society. It also had other important results which will benefit this Society and this Faculty. A new record for attendance was established and the event has been characterized as an unqualified success.

An attempt has been made this year to provide accommodation for a reading room in the library, and as a mere beginning covers were provided for the magazines. Of course the accommodation is quite inadequate to our needs but it was thought advisable to insert the thin edge of the wedge at this time. Then when the new buildings are being planned, rooms will be set apart for this purpose.

Much of what has been accomplished during this last year can be directly attributed to the strong Executive Committee which you elected a year ago. This committee has worked earne stly and conscientiously and has devoted a great deal of its time for the welfare and upbuilding of the Society. It has been a privilege for me to be associated with the work of this committee, and I assure you that the executive deserves your thanks.

In conclusion, let me thank the members of this Society for the honor they conferred upon me a year ago in electing me to this position. In giving an account of my stewardship I hope that I have merited, to some extent the confidence they placed in me at that time.

I have much pleasure in presenting to the Society their President-elect for 1909-1910 Mr. D. W. Black.

Yours sincerely

ROBERT J. MARSHALL.

TREASURER'S REPORT.

RESOURCES REALIZED 1907-08.	
By cash balance	$329 73
Supply	46 00
Ads. *Applied Science*	411 23
Dinner Account	2 00
Outstanding accounts received	35 75
	$824 71
RECEIPTS 1908-09.	
Sales Supply Dept.	$4,522 68
Fees	901 00
Sundries	294 70
Ads. *Applied Science* and Subscriptions	240 63
Grant to *Applied Science*	155 00
Rec. Dinner Account	524 40
	$7,463 12
RESOURCES FROM 1908-09.	
226 Orders on Deposit	$ 395 50
Bank balance	99 53
Outstanding due Supply Dept.	95 11
Cost Price Stock	2,319 91
Outstanding, due *Applied Science*	619 09
	$3,529 14
LIABILITIES FROM 1907-08.	
Outstanding accounts	$125 32
Printing *Applied Science*	651 28
	$776 60
DISBURSEMENTS.	
General expenses	$ 266 69
Supply Dept.	3,912 10
Sundries	716 01
Dinner	1,128 30
Applied Science	563 89
Bank balance	99 53
	$7,463 12
LIABILITIES FROM 1908-09.	
Sundry outstanding acounts	$ 145 25
Against supply	913.45
Against *Applied Science*	429 78
Surplus	2,040 66
	$3,529 14

We, your auditors, do hereby certify that we have examined the books and accounts with vouchers of your Society for the year from Mar. 27, '08, to Mar. 27, '09, and that the above statement exhibits a true and correct view of the financial standing of the Society as shown by the books of the society.

It was impossible to make more than a superficial audit of the supply department, but if the system, as now proposed by Mr. MacKenzie is carried into effect this coming year, the system of checking executed by the Treasurer and Vice-President will be more or less of a daily audit on the supply department, and if then a thorough audit was made at the end of the year, the system of accounting would, in our opinion, be all that could be desired.

S. R. CRERAR
R. S. DAVIS,
Auditors.

Toronto, April 15, '09.

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Editorial

The Widening Field of the Engineer

This is an era of expansion and conformably with the change in commerical conditions the function of the engineer is rapidly enlarging. From his capacity of an engineer, limited to the determination of technical questions, the engineer of to-day has come to assume an economic importance in those branches of industry dependent upon engineering skill for development.

He is indeed an engineer of limited usefulness who does not go farther professionally than to submit a purely technical report on the subjects presented for his consideration. While he has the same responsibility as formerly in the solution of the technical problems involved, he is further expected to supplement his report with advice on the financial and commercial

aspects of these problems. For the great majority of problems presented to the engineer ultimately involve the determination of the pecuniary relations of the proposition under discussion.

This is a phase of engineering education which has been sadly neglected, with the result that the average engineer gets the scientific part ground into him to such an extent that he never gets into the real game and seldom takes his proper place in the community.

Owing to the ever widening field for engineers which is embracing all sorts of business the purely scientific engineer is becoming a very decided minority. One of our most prominent graduates took stock of his work recently and found that from two-thirds to three-fourths of his time was taken up in what might be called the business side of engineering and very little with purely technical matters. In other words reporting on and operating properties and dealing with business situations was of greater importance than his purely technical work, besides it paid much better

The question arises can this commercial side of engineering be recognized in the curriculum of an engineering college? While it cannot be hoped that an art such as business is can be taught in schools where science is the main subject—a course of lectures could be of value if they indicate to the student that there is a world outside the purely technical that is awaiting him, and which he can occupy if he will recognize the fact that it is his. This century belongs to the engineer more even than the last. We recognize this broadening field and his education has got to cover it. The only difficulty will be the overloading of the student who already has more subjects than he can conveniently assimilate. So much is the case that he really has little time to think for himself, but only to absorb lectures. Does the answer lie in cutting out some of the more purely scientific subjects or demanding a higher standard of entrance? However, let the details of working out be what they may, it is expedient that the University of Toronto should do something in this line, and not let her rivals outdistance her. No criticism is more often heard of the young graduate than that he does not understand business. This criticism is made by the man who will employ him. Our graduates should therefore be in a position to understand something of the rules of the game, so as to be able at least to talk intelligently to the financial man, with whom he will inevitably have to deal.

The Ideal Lecturer

Much has been written from time to time about the ideal teacher in secondary education, but for some reason very little has been said about the ideal lecture and lecturer in higher technical education. At the same time there is no class of men who lecture before a student body which is so capable of giving an intelligent criticism in its broadest sense of what is

offered them. This criticism, picking out both good and bad, would be welcomed by all professors and lecturers who sincerely pray with Burns, "O waud some power the giftie gie us to see oursel's as ithers see us."

With this end in view, Professor Haultain has offered a prize of the choice of a book on engineering to the undergraduate or graduate submitting the best essay of two or three thousand words on the Ideal Lecture and Lecturer in Technical Education. These essays will be of course impersonal. Pseudonyms may be obtained from the President of the Engineering Society. The judges will be E. A. James, Editor, Canadian Engineer; J. C. Murray, Editor, Canadian Mining Journal; K. A. MacKenzie, Editor, Applied Science. The essays are to be submitted on or before February 1st, 1909, and will be printed in the February Applied Science.

The School Reunion Dinner.

It has been definitely decided to hold the annual dinner of the Engineering Society on either Wednesday or Thursday of the last week in January. It is expected that this will be the climax of a series of such functions. All circumstances seem to be working together to ensure its success. The original plan of having a reunion dinner for both graduate and undergraduate bodies is still in view, but added to this it has been decided to take advantage of the fact that the annual meeting of Canadian Society of Civil Engineers is being held in Toronto, for the first time, on that date.

This in itself will attract to the city a great number of our graduates, who are connected with the larger society.

Added to these it is hoped a number from a distance will be attracted by the cheap fares available on the railroads.

A thoroughly organized effort will be made by the members of different graduating years to get a large representation out. All graduates are urged to turn in and make the dinner a memorable one. It will undoubtedly be a success.

It is just possible that there may be some who harbor a feeling of resentment at not being invited to the presentation of the portrait to the university. As it was not thought advisable to in any way detract from the success of the dinner by splitting the attendance on the two occasions, hence only the city graduates were specially invited.

There will be a meeting and dinner of the graduates of the School of Practical Science and of the Faculty of Applied Science of the University at the St. Charles Hotel on Tuesday evening, December 15th at 6 o'clock.

THE ENGINEERING SOCIETY.

The Engineering Society held its second general meeting on Wednesday, November 4, at 8 p. m., in the University Convocation Hall. That the meeting was enthusiastic and largely attended goes without saying, it being the occasion of an event that will go down with honor and distinction in the records of the Engineering Society—viz., "The Presentation of the Portrait of Dean Galbraith" to the Board of Governors of the University. It was brought about through the combined efforts of the graduates and undergraduates of the Faculty of Applied Science.

Among those present on the platform were President Falconer, Dr. Hoskin, E. W. Stern, Prof. Haultain, Dr. Ellis and Dean Galbraith. After a very fitting address, and a few humorous remarks, bringing back fond reminiscences of the early days at the School, Mr. E. W. Stern, one of the School's early and most distinguished graduates, presented the portrait, which was received, on behalf of the Board of Governors, by Dr. John Hoskin, who in a few well chosen words, thanked the graduates and undergraduates for the great honor they had bestowed on the University, and at the same time paid numerous compliments to the worthy original. President Falconer and Dr. Ellis were quite profuse, and rightly so, in their praises for Dr. Galbraith, enumerating the many things he had done in the interests of the students in engineering and of the engineering profession in general, and also the parts he had played in the uplifting of the standard of the Faculty of Applied Science to the proud position it now holds. H. E. T. Haultain, our recently appointed professor of mining engineering, and a graduate of the School, addressed the meeting and took great pride, he said, in being able to compare our graduates most favorably with graduates of any other technical school in the world. Dean Galbraith was then called upon to address the meeting. He thanked the graduates and undergraduates for the honor they had done him, and then gave them an idea of the pleasant task he found that of sitting for a portrait to be.

On November 18, the regular sectional meetings were held. At the Mechanical and Electrical sectional meeting papers were given by Mr. F. Hagerman, '09, on "The Installation of the College Telephone System," and by Mr. C. Hughes, '09, on the "Toronto Waterworks Tunnel." The papers were well written, and especially well delivered. Both being of local interest they provoked a considerable amount of discussion, in which many good points were brought out.

The regular Civil and Architect sectional meeting was addressed by Mr. C. F. King, a graduate of the School in '98 and a past president of the Engineering Society, on "Conditions in Northern Canada." Mr. King was a member of the famous Neptune expedition sent out by the Dominion Government for exploration purposes in the Far North.

WHAT THE GRADUATES ARE DOING.

E. W. Stern, on whom the honor fell of presenting the portrait of Dean Galbraith to the University, may be regarded as one of the "School's" most successful graduates. He was born in Toronto, August 20th, 1865. After obtaining his diploma in 1884, he entered railway work on the old Northern and Pacific Junction railway, first as rodman and then as assistant engineer in charge of construction. Returning to the School the following year he became one of its first Fellows, and on leaving he entered the employ of the Passaic Rolling Mill Co., Paterson, N. J. With this company he was employed mostly on the shop plans of the Washington bridge over the Harlem river, a 500 ft. girder arch. In 1887 he went west to Chicago as an assistant engineer on construction of the cable railway. He, however, soon left this to enter the employ of the Chicago Bridge & Iron Co. From this period on his time has been employed almost entirely on the design and construction of steel structures of various sorts—bridges, roof trusses, buildings, etc. Such structures as the bridge over the Mississippi at Winona, Minn., and the Coliseum at St. Louis are examples of his work. He returned east to New York in 1898 as chief engineer of the Jackson Iron Works. While with this company he was in full charge of the design and supervision of construction of buildings, the contract price of which amounted to nearly three million dollars. From 1902 to the present he has been engaged in professional practice as consulting engineer, making a specialty of buildings and foundations. During this period he has designed or supervised the constructional work of fifty-three buildings, the contract price of the engineer's work of these amounting to about four million dollars. Among these are the new Terminal station at Hoboken, N.J., the new ferry stations at 23rd Street, New York, for the Lackawana & Erie Railroads; the B. Altman's store at Fifth Avenue and 35th Street, National Park Bank, Travelers Insurance Co., Hartford; New York Evening Post, State Library and Supreme Court Building, Hartford. He was associated with S. C. Weiskopf on the construction of the thirty-two storey City Investing Building on pneumatic caisson foundations; also on the Union Passenger station, Chattanooga, Tenn., and the State Armory, Hartford, Conn. He was elected a member of the American Society of Civil Engineers in 1897. In 1899 he married Miss Dorothy Kohn of New York. He has two children, Helen, aged 8, and Theodore, aged 1 year.

B. Nielley, '07, has accepted the position of assayer at Silver Queen mine, Cobalt.

N. P. F. Death, '06, is with Death & Watson, electrical engineers and contractors. They are specializing on illumination.

Frank Barber, '06, has been appointed county engineer of York County.

Index to Advertisers

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Editorial

To the Graduates

The vindication of an effort is its object and the result obtained. The best advertisement of an institution is its men. The good name of an institution consists in more than the reputation of the personnel of its staff, and its history in more than a record of its growth in numbers and buildings. It has been shown for years that the best advertisement of the Faculty of Applied Science is the list of graduates showing the positions held by each as published annually in the calendar. With the increasing numbers graduating yearly, the difficulty of having this information as complete as desired has also greatly increased. It is most important both from the standpoint of the institution but more particularly from that of the graduate, that the secretary of the Faculty should be promptly informed of all profes-

sional engagements or changes, and to this end the co-operation of each graduate is earnestly solicited. It is desired to make the office of the secretary the headquarters for all such information. The staff views with justifiable pride and satisfaction the reputation given to the institution through the achievements of its graduates and fully recognizes the important part played by them in this connection. In this there has been a laudable spirit of reciprocation, never made more evident than at the last annual dinner, when the institution was brought more prominently into public notice probably than on any previous single occasion. On the one hand the staff, through the senior members, gave free expressions of appreciation of the loyalty with which the graduates had always supported their Alma Mater; on the other hand the graduates were unstinted in their praises of the work done by the institution and thus was manifested that spirit of unity which to a large extent accounts for its prestige in the community at the present time.

There is no doubt that the history of the institution in the broader sense would constitute interesting literature. That part which deals with its growth, buildings and equipment can be obtained through the records and is definite, and is dealt with elsewhere in this issue. There is another part, less definite, it is true, but of equal and ever increasing importance, which might be written upon the experiences and achievements of the graduates and the important and influential part these achievements have had upon the national and industrial development of the country.

We Want a Complete Record of Graduates

With a view to collecting this kind of information, it is proposed to issue printed forms to the graduates, asking their co-operation in the acquiring of a systematic professional record to be kept in the office of the secretary. The object of such a record is clear and should appeal to every graduate. It will be used as a means of securing employment for and of furnishing assistants to those desiring such. It is true this feature will appeal more strongly to the younger graduates, but there are many ways in which the information can be made mutually helpful to all and a hearty support of the scheme is solicited. It is needless to say that the information received in this connection will be treated in strict confidence, such of it being used from time to time as will advance the interests of those concerned.

Cooperation Among Graduates

The older graduates are to be commended for the way in which they have sought to place the younger men when in need of assistance, and it is desirable that this spirit should be stimulated. The Graduates' Association in New York has taken an important step in this direction in that it has placed itself at the disposal of the younger men who go to that

city for employment. Those who go to New York are asked to call at the office of Mr. E. W. Stern, where they will be cordially received and will also be given any information within his power of the association.

Elsewhere in this issue appears a list of graduates whom we desire to locate. We would gladly welcome any information regarding their location and employment.

Let us hope that in the future the graduates will keep the secretary more promptly informed as to their changes and also that they will freely assist in the movement for a complete professional record.

THE FIRST ANNUAL DINNER

In the first section there appears a cut of a menu card of the first dinner twenty years ago. It is interesting to glance over the list and note what has become of this old guard. On the whole, they have all been successful in life. Of the fifty-one present at the dinner January 31st, 1890, twenty-two were present at the reunion dinner last month. Of the number, nine are known to be dead.

C. H. Topp is city engineer of Victoria, B.C.

W. E. Boustead is dead.

T. H. Wiggins is with the Department of Public Works, Regina, Sask.

J. R. Pedden, address unknown.

F. M. Bowman is one of the chief engineers of the Riter Conley Mfg. Co., Pittsburg, Pa.

E. B. Merrill, after being associated with several of the most important hydro-electric developments in Canada, is a consulting engineer in Toronto.

J. B. Hanly is in manufacturing business at Midland, Ont.

Andrew Lane is deceased.

R. McLennan, address unknown.

J. M. Prentice is dead.

T. H. Alison is chief engineer of the Augustus Smith Co., New York.

A. F. Macallum has just been appointed city engineer of Hamilton, Ont.

J. E. A. Moore is a consulting and contracting engineer in Cleveland, Ohio.

G. E. Silvester is chief engineer, Canadian Copper Co., Copper Cliff, Ont.

C. W. Dill is one of Toronto's leading contractors.

N. L. Playfair is superintendent of Playfair Lumber Co., Midland, Ont.

N. M. Lash is assistant electrical engineer for Bell Telephone Co., Montreal.

R. J. Christie is manager of the Christie Biscuit Co., Toronto.

R. A. Ross is associated with Mr. Holgate, and is considered one of Canada's leading electrical engineers.

J. Hutcheon is city engineer of Guelph, Ont.

J. Galbraith, the Dean, is known to all Canadians.

John A. Duff is deceased.

W. H. Ellis is Professor of Applied Chemistry at the University.

C. H. Mitchell is a consulting electrical engineer in Toronto and Niagara Falls.

L. B. Stewart is Professor of Surveying.

J. E. Jones is with a prominent firm of New York consulting engineers.

J. H. Chewett is president Evans Rotary Engine Co., Toronto, Ont.

C. J. Marani is designing and consulting structural engineer for the Russia Cement Co., Anacortes, Wash.

V. G. Marani is a consulting engineer in Cleveland, Ohio.

C. M. Canniff is chief engineer of the Expanded Metal Co. of Canada.

H. Rolph is vice-president, Metcalfe Engineering Co., Ltd., Montreal, Que.

T. R. Russell is a clergyman in Virginia, U. S.

J. W. Evans is a mining engineer, Toronto and Cobalt

Wm. Newman is a consulting engineer at Windsor, Ont.

A. G. Anderson is a hardware merchant at Port Dover, Ont.

G. L. Brown, civil engineer and surveyor, Morrisburg, Ont.

R. Russell, civil engineer and surveyor, Pembroke, Ont.

A. R. Goldie, with Goldie & McCulloch, Galt, Ont.

E. J. Laschinger, M.E., is with the Consolidated Gold Fields Co. of South Africa, Johannesburg, Transvaal, S.A.

A. B. English is deceased.

M. A. Bucke is deceased.

Albert Smith is engineer with W. B. Pollock Co., Youngstown, Ohio.

C. E. Peterson, address unknown.

J. E. McAllister is manager of the British Columbia Copper Co., Greenwood, B.C.

H. D. Symmes is a contractor at Niagara Falls, Ont.

W. B. Russel is an engineer and contractor in Toronto, but lately largely interested in Cobalt properties.

Thos. R. Deacon is president and general manager of the Manitoba Iron Works Co.

M. Dunbar is deceased.

G. Robertson, address unknown.

W. L. Innes is manager, Canadian Canners, Ltd., Simcoe, Ont.

H. Meade, address unknown.

G. D. Corrigan is deceased.

LIST OF GRADUATES WHOSE ADDRESSES ARE UNKNOWN.

Below is a list of graduates whose addresses we have been unable to verify. These men must be known to some. Make it a personal matter to notify "Applied Science" in case you can supply the information desired.

1882—D. Jeffrey.
1885—E. E. Henderson.
1887—A. E. Lott; F. Martin.
1888—D. B. Brown; J. Gibbons.
1889—B. Carey.
1892—J. R. Allan.
1893—W. Mines; R. H. Squire; H. P. Barker.
1894—A. C. Johnston; A. L. McTaggart; S. M. Johnston.
1895—W. M. Brodie; H. S. Hull; R. J. Campbell.
1896—H. P. Elliott.
1897—A. T. Gray, M. B. Weekes, W. R. Smiley, E. A. Weldon.
1898—J. E. Lavrock; J. A. Stewart.
1899—G. A. Clothier; J. C. Elliott; E. Guy; G. E. Revell; C. Cooper; W. E. Foreman; G. A. Saunders.
1900—J. H. Barley; H. A. Dixon; J. C. Johnston; J. G. McMillan; A. Taylor; J. E. Davison; H. S. Holcroft; R. E. McArthur; J. R. Roaf; H. M. Weir.
1901—F. C. Jackson; C. MacMillan; W. C. Lumbers.
1902—J. M. Brown; F. T. Conlon; A. C. Goodwin; R. S. Mennie; H. J. Zahn; W. Christie; H. V. Connor; C. H. Marrs; H. D. Robertson.
1903—J. G. R. Alison; J. A. Horton; M. L. Miller; F. A. Moore; J. P. Oliver; R. E. George; C. A. Maus; R. H. Montgomery; E. E. Mullins.
1904—A. M. Campbell; O. B. McCuaig; C. P. McGibbon; E. E. Moore; J. M. Weir; P. C. Coates; G. G. McEwen; D. McMillan; W. J. Smither.
1905—R. H. Armour; R. B. Ross; F. H. Sykes; D. W. McKenzie; T. E. Rothwell.
1906—W. MacKinnon; R. E. Pettingill.
1907—E. Cavell; G. S. Stewart; S. A. Marshall; A. C. T. Sheppard.

ENGINEERING SOCIETY.

The interest in the meetings of the Society was fully sustained during the month, the regular, general and the sectional meetings being held.

The general meeting was addressed by T. W. Gibson, Deputy Minister of Mines, of the Province of Ontario. Mr. Gibson spoke on the Mineral Resources of Ontario; it was a valuable

contribution by an authority on the subject. Dean Galbraith and Prof. Haultain took part in the discussion which followed.

On Jan. 20th, the Civil Section listened to an address on the "Detroit River Tunnel Construction," by Mr. C. T. Hamilton, '08. Mr. Hamilton was on this work since its inception and had the story of the undertaking well in hand, and fully illustrated.

The discussion which followed was lead by Messrs. P. Gillespie and C. R. Young.

The Mechanical Section had a double bill. R. Cunningham, '09, spoke on "The Electric Furnace," and H. Irwin, '09, on "Mining and Reduction of Copper Ores."

The Chemical Section provided a joint paper by D. J. Huether, '07, and L. J. Rogers, '07, on "High Temperature Measurements." Dr. Ellis and Prof. Bain spoke briefly at the conclusion of the paper.

UNIVERSITY OF TORONTO ELECTRICAL CLUB

A short synopsis of the work done by the club for the present college term will give a fair idea of its possibilities and of the benefits derived by its members. There necessarily is some delay at first, owing to the fact that third year has to be approached and that the greater part of the executive has to be elected.

On November 5th H. Coyne, '08, gave a paper on "Cranes and their Equipment," on November 19th F. H. Moody, '08, read a paper on "A Locomotive Testing Plant at St. Louis," and on December 10th a paper on "The Interpole Motor" was delivered by F. R. Ewart, B.A. Sc, '07, after which W. W. Gray, B.A.Sc., '04, gave an interesting talk on "Producer Gas Plants." All four papers were illustrated by lantern slides. The discussions following have been spirited, indicating the interest taken by the members.

In the spring term four meetings were held. The first meeting in January was devoted to the reading and discussion of a paper on "Electric Traction" by V. C. Thomas and J. N. Leslie. Later in the month Mr. W. H. Price gave a practical demonstration of the oscillograph. The club was indeed fortunate in this—a repetition of his paper before the Canadian Electrical Association. The third meeting was taken up with the discussion of L. S. Odell's paper on Steam Turbines. At the final meeting L. S. Davis read a paper on Rotary Converters.

At the final meeting a change was made in the constitution, changing the name of the club to the University of Toronto Electrical Club. It was also decided that the two councillors of the third year should be chosen, one from the electrical and the other from the mechanical section. This was done to bring the mechanicals more closely in touch with the society.

The executive for next year will consist of N. Porter, presi-

dent, and E. A. Thomson, secretary-treasurer, the councillors being chosen in October.

During the year excursions were made to inspect the various industries in and around Toronto.

The executive finds engineering firms eager to get into touch with the club and it has received a number of excellent instruction books and bulletins.

The undoubted success of this club should inspire the formation of a similar one in the Civil Department.

THESIS FOR B.A.Sc. DEGREE

The following are the subjects of the thesis submitted by the members of the fourth year, for the degree of Bachelor of Applied Science. The subjects this year are unusually general, and all exhibit a commendable degree of research both in reading and original work.

H. G. Akers, Factory Testing of Electric Machinery; W. L. Amos, Lightning Protective Apparatus for Transmission Lines and Stations; W. S. Brady, Electric Railways; P. R. Brecken, Irrigation; J. A. Brown, Concrete, Plain and Reinforced; F. H. Buchan, Storage Battery Engineering; C. E. Bush, Concrete Arches; A. W. Campbell, Modern Electric Street Railway Practice; H. R. Carscallen, Hydrographic Surveying; F. H. Chesnut, Railroad Construction; W. C. Collett, Design of a Terminal Station; R. Y. Cory, Canals; G. C. Cowper, Masonry and Concrete Dams; H. Coyne, The Induction Motor; J. V. Culbert, Cyaniding of Gold and Silver Ores, with Special Attention to those of Ontario; A. D. Dahl, A Study of the Black Liquor from the Soda Process for the Manufacture of Wood Pulp; R. S. Davis, Rotary Converters; F. C. Dyer, Concentration of Slimes; C. Edwards, Steel Rails; O. L. Flanagan, Water Supply; A. H. Foster, Concrete, Plain and Reinforced; S. S. Gear, Water Turbines; A. Gillies, Reinforced Concrete Arch; C. L. Gulley, Induction Motors; J. W. Hackner, Producer Gas Engines; K. Hall, Transformers; C. T. Hamilton, Detroit River Tunnel as Constructed from the Windsor Approach; M. C. Hendry, Piles and Piling; D. J. Huether, Chemistry of Carbon Monoxide; A. D. Huether, Foundations and Retaining Walls; A. N. Hunter, D. C. Railway Motors; S. B. Iler, The Synchronous Motor; W. Jackson, Irrigation; J. D. Keppy, Suction Gas Producers; F. C. Lamb, The Pendulum; J. N. M. Leslie, Heavy Electric Traction; L. A. McLean, Base Line Measurements; H. C. McMordie, Irrigation; A. A. McRoberts, The Filtration of Public Water Supplies; R. J. Marshall, Dams and Retaining Walls; J. B. Minns, Transformer Design; E. D. Monk, Electric Power Transmission Line Construction; F. H. Moody, Special Features of Modern Steam Locomotives; J. H. Morice, Switchboards and

Switchboard Apparatus; F. E. H. Mowbray, The Induction Motor; C. R. Murdock, Hydraulic and Placer Mining; W. P. Murray, Steam Locomotives; E. W. Murray, Roads, Their Construction and Maintenance; H. J. Peckover, Municipal Thoroughfares; M. Pequegnat, Sewage and the Disposal of Sewage; M. Pivnick, Gas Engines; F. E. Prochnow, Polyphase Induction Motors; E. M. Proctor, Irrigation; C. F. Publow, Single Phase Series Commutator Type Motor; J. T. Ransom, Time; W. B. Redfern, A General Description of the Hydraulic Features of the Power Plants at Niagara Falls; A. R. Robertson, Concrete in Municipal Work; R. R. Rose, The Concentration of Sands; W. E. L. Shaw, Lightning on Transmission Lines, Cause, Effect and Remedy; H. F. Shearer, Synchronous Machines; W. L. Stamford, The Development of Water Power; R. H. Starr, Electric Car Equipment and Traction; R. B. Stewart, Magnetic Separation of Ores; W. M. Stewart, Precise Levelling and Determination of Elevations; J. L. Stiver, Comparison of the Hydraulic Construction of the Niagara Falls Power Plants; R. B. Stuart, Dams—Their Design and Construction; G. F. Summers, Concrete Dams; V. C. Thomas, Steam Railroad Electrification; J. H. Thornley, Water Power Development in Canada; R. M. Wedlake, Electrical Illumination; W. J. White, The Electric Drive on Draw Bridges; F. D. Wilson, Internal Combustion Engines; A. R. Zimmer, The Distribution of Electric Power.

WHAT THE GRADUATES ARE DOING.

G. Galt, B.A.Sc., '07, is at the Northern Lode Mine at Greenwood, B.C.

C. W. Hookway, '06, is with the Allis-Chalmers-Bullock Co., at Montreal.

B. F. Mitchell, B.A.Sc., '06, is in the city engineer's office at Calgary, Alberta.

Geo. S. Hodgins is editor of Railroad and Locomotive Engineer, New York.

A. F. Macallum, '93, has been appointed City Engineer of Hamilton, Ontario.

Walter Malcolmson, '07, is in the office of the city engineer, Niagara Falls, Ontario.

H. V. Serson, '05, is with the Taylor Iron and Steel Co., High Bridge, New Jersey.

D. J. McGugan is on the engineering staff of the Sumas Development Co. at Chilliwack, B.C.

F. A. Danks, '08, is in the office of Hazen & Whipple, consulting engineers, 103 Park Ave., New York.

A. L. Ford, '04, is Government Inspecting Engineer on G. T. P. Railway from Winnipeg to Saskatoon.

C. Fairchild, '92, and W. G. Webster, '05, have formed a partnership, with offices at Brantford and Dunnville.

A. F. Macallum is associated with T. Aird Murray in reporting on a scheme of sewage disposal for New Toronto.

J. M. Wilson, '08, is general manager of W. H. Oliver Co., Chemical and Mechanical Engineers, McKinnon Bldg, Toronto.

A. G. Christie, '01, has been appointed Research Assistant in the Department of Mechanical Engineering at the University of Wisconsin.

S. Wass, '03, has been transferred from Durham to the Toronto office of the construction department of the Canadian Pacific Railway.

Edw. O. Fuce, '03, is located at Galt, Ont., as a consulting civil engineer, specializing on sewage disposal and reinforced concrete work.

G. S. Hanes, '03, till recently City Engineer of Windsor, is now City Engineer of North Vancouver. M. E. Brian, '06, will succeed him at Windsor.

E. V. Neelands, B.A.Sc., has been appointed manager of the Hargrave Mine at Cobalt. G. Johnson is manager of the Silver Cliff mine in the same camp.

W. J. Francis, '93, read a paper before the Ontario Association of Architects at their recent convention, on "The Economical Advantages of Reinforced Concrete."

F. W. Thorold, '00, for some time City Engineer of Calgary, Alberta, has been appointed assistant engineer in charge of outside work on Toronto's new sewage system.

Frank Barber, '06, appeared before the Railway Commission in the recent viaduct case in Toronto to give evidence that an economical viaduct could be built on oblique piles.

W. Fry Scott, '97, consulting structural engineer, has been retained by the Mutual Fire Insurance Company to give manufacturers skilled expert advice on matters of construction and protection.

We regret to report the death of Duncan Sinclair, B.A.Sc., '02, a former president of the Engineering Society, on January 5th last. A full obituary of him, along with others, will appear in No. 6, Applied Science.

S. L. Fear is with the Dunbar & Sullivan Dredging Co. of Buffalo. They are operating at present on the new Livingston Channel—a four-year contract—Detroit River, 24 feet deep, 300 wide, and about 18 miles long.

We regret to report the death of W. F. Ratz, '02, at Ottawa, from typhoid fever. Mr. Ratz had for some years been on the international survey between Canada and Alaska. A full obituary will appear in number six issue.

A. R. Campbell, '02, and A. L. MacLennan, '02, have forsaken engineering for the present and are engaged in manufacturing of a new vacuum massage machine, Mr. Campbell being president and managing director of the Universal Manufacturing Company.

J. D. Shepley, '04, district engineer for Battleford, Sask., called at the school, renewing old acquaintances. He spent this summer running a line north from North Battleford to get in touch with the fur trade of that district. The district is very rough and for some distance covered with fallen timber.

H. D. Symmes, '91, has just finished the contract for the 150-foot extension of the Ontario Power Company's plant at Niagara Falls, in record time. The work included some very complicated concrete construction which, considering the nature of the ground and the location of the plant, was finished with remarkable despatch.

Mr. C. H. Mitchell, C.E., has now associated with him in partnership his brother, P. H. Mitchell, and together they will carry on practice as consulting and supervising engineers. Mr. C. H. Mitchell is too well known to need mention of his work. His brother is also a graduate of Toronto and has had a wide experience in mechanical and electrical engineering, having for some years been employed on the works of the Ontario Power Co. at Niagara Falls and on the Winnipeg Municipal Power Plant, as well as several steam and electric plants. The new firm will attend especially to hydraulic and steam-driven electric power plants, electric railways and electric lighting.

Messrs. Gardner and Wilson, both '03, have opened an office in Niagara Falls, Ontario, to carry on a general practice. They will give special prominence to electric railway and hydro-electric work. J. C. Gardner, B.A.Sc., has been for twelve years on engineering work, having been connected with the construction of the three bridges across the Niagara River below the Falls and of the power houses of the Niagara Falls Power Co. and the Ontario Power Co. He was two years with the Toronto and Hamilton Railway, going to Chili early in 1906 to work on the construction of the Anca and La Paz Railway through the Cordilleros. N. D. Wilson, B.A.Sc., spent two years on bridge and city work, and a year in the office of the late W. T. Jennings, C.E. in connection with the Toronto and Niagara Power Company. He has been on location and construction in Ontario and the West for the G. T. P. and C. P. R.

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Editorial

The Young Civil Engineer

Mr. Stern's paper, "The Young Civil Engineer," which appeared in the January Applied Science, is discussed most fully and ably in this number. A great number of the undergraduates and the recent graduates are now at the cross-roads of life and will do well to carefully study not only the discussion but again read the original article. The men who have so kindly contributed are leaders in their profession in America, men who have been through the fight of life in some of its most strenuous scenes, men who have wrestled with opportunity and come out victors, and therefore men whose opinions must and do carry weight.

Too often the young graduate will sacrifice future success

for present gain. They seem to forget the fundamental point of all building, that no matter how fine the superstructure is made, if we build high the foundation must be solid.

The Toronto Graduates' Association

The most successful of the series of dinners of the Toronto Graduates was held on Friday, March 12th. Nearly one hundred members were present. These gatherings have stimulated wonderfully the interest of the graduates in the welfare of the School. It speaks volumes for the loyalty of the Science Alumni that such a large percentage should be present. Much can be done by such an organization and steps were taken to put it on a more permanent basis. The following officers were elected for the year: President, E. Richards; Vice-President, W. Douglas; Secy.-Treasurer, K. A. MacKenzie; Committee—W. E. H. Carter, J. C. Armer, W. D. Black, president-elect of the Engineering Society.

A resolution was passed instructing the secretary to communicate with the Board of Governors, pointing out to them the great need of a new Engineering building.

After the meeting the members adjourned to the University gymnasium, where the Engineering Society elections were being held. A full report of the elections will be given in April issue.

Readers of the British technical press of late have been interested in a very excellent illustrated article on "Engineering at the University of Toronto," by Mr. Walter J. Francis, C.E., of Montreal, a distinguished alumnus of the School of Practical Science. Mr. Francis' paper appeared in a recent issue of The Engineer, is partly historical, partly descriptive of present conditions, and partly anticipatory of future developments, and the statistics supplied will give to the British reader particularly, some conception of the phenomenal growth of this Faculty during the decade just closed. It is of interest in this connection also to mention the fact that Mr. Francis contributed to the recent convention of the Canadian Cement and Concrete Association in Toronto an authoritative paper on "Field-Made Concrete." Mr. Francis' extended experience on engineering works of magnitude in Quebec, Ontario and British Columbia enables him to handle such a subject as this in a masterly way. He is possessor of a bright and readable English style.

R. W. Angus, Professor of Mechanical Engineering, left this week for an extended trip to Europe. His object primarily is to inspect the thermo-dynamic and hydraulic laboratories of the universities of Great Britain and the continent, with a view of incorporating their better features in our new laboratories, now

nearing completion. As Prof. Angus has already visited those of the leading American and Canadian universities and as no reasonable expense has been spared, it is to be expected that the Toronto ones will rank among the best in the world.

Professor Angus desires to acknowledge the appreciation of the University of the following presentations of machinery and apparatus, recently offered by various companies. Among those which have already been presented may be mentioned:

Two Leonard engines with different types of slide valves by E. Leonard & Sons, London, Ont.

One rock drill by the Sullivan Machinery Co., New York, through Mr. A. E. Blackwood, '95.

Marine gasoline engine by the Canadian Fairbanks Co., Montreal, Que.

Two water meters by the National Meter Co., New York, through Mr. M. Warnock, Toronto.

In addition to the above gifts, considerable apparatus has been supplied at very low prices, among which should be specially mentioned a Rand air compressor, supplied by the Canadian Rand Drill Co. through Mr. H. V. Haight, B.A.Sc. These indications of practical sympathy with the work which we are doing are much appreciated and it is hoped that other firms will assist us in the same way in so far as it is possible.

PROF. C. H. C. WRIGHT HONORED

Some people are so unfortunately constituted that they do not seem able to remember pleasant, agreeable things. The uncharitable and disagreeable so dominate their lives that the happy experiences are forgotten or crowded out.

Not so with the body of men, the past presidents of the Engineering Society of the Faculty of Applied Science of Toronto University, who met in Toronto on the evening of March 30th to do honor to C. H. C. Wright, B.A.Sc., professor of architecture in the Faculty of Applied Science of Toronto University. In their college days they recognized, and have since remembered, the man who, with unfailing good temper, willing always to do his share of the work and more, with a word of congratulation, encouragement or "ginger," inspired, and, by his kindly interest, made pleasant and profitable their year of responsibility as presidents of the students' organization.

Charles Wright was born on shipboard in Chelsey Harbor, Massachusetts, in 1864, and spent his boyhood days in the fishing town of Digby, Nova Scotia. From here he moved to Kingston, Ontario, where he spent three years in the public schools. In 1880 he entered the Pickering College, and under its principal, J. E. Bryant, received his mathematical inspiration.

In the fall of 1885 he registered in the department of civil engineering at the School of Practical Science, Toronto. As a student, he was successful both in the athletic field and in the examination hall, securing in examinations more first places than any other two men of his year.

With his classmates he was popular and was elected to the highest position in the gift of the Engineering Society. His field experience, since graduation, was secured with a Boston firm of building contractors, with whom he rose to the position of chief of the estimating staff. But his work seemed to be academic, and in 1890 he joined the staff of the School of Pratical Science as Lecturer in Architecture. By constant thought, continual study and unfailing industry, he became an authority on materials of construction and on design.

It was not to Wright the student or the college professor that these men assembled to do honor, but to Wright the man and the friend of every undergraduate and graduate of the Faculty of Applied Science. For eighteen years he has planned and worked and organized. He has studied methods and studied men and studied the situation. He has made himself familiar with the conditions in the schools below and in the faculty, in the university at large and in the profession; has weighed carefully the situation, and, having decided on the proper course, has the sand and the staying power to maintain his stand.

All these labors and preparations were undertaken not for selfish reasons, but because he had vision and faith in the future of his profession and of this young country, and that conditions are changing rapidly, and that new policies must be devised to meet the new problems.

The honor done Mr. Wright struck a responsive point of contact among the graduates of his alma mater and in the public mind, and many kindly thoughts and messages will be sent in his direction, for men realize that removed from the grinding routine and petty annoyances of clerical work he is a bigger man; he grows.—E. A. James, in Canadian Engineer.

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Editorial

Dean Galbraith

"Occasionally a man comes into the fruition of his life work while there is yet time to make it complete in the stimulating joy of appreciative recognition." This applies with special force in the case of Dean Galbraith. Largely through his initiative and untiring energy, the present Faculty of Applied Science of the University has developed from a very humble beginning to almost a commanding position among the Faculties. It will ever remain a fitting monument to his honor and to his memory.

To few men has the privilege and power been given to so indelibly stamp his impress upon those with whom he came in contact. The only regret is that the increasing growth of the School renders it impossible for undergraduates to come in

personal touch with the Dean, as was the case in less prosperous days.

It was with considerable pleasure that the graduate and undergraduate bodies united to present his portrait to the University to show their appreciation of him. It is the earnest wish of all that he may be long spared to continue the work he has so ably planned and carried on to its present successful issue.

Prof. G. R. Mickle

Prof. George R. Mickle, who has been with the School of Practical Science for fourteen years, first as Lecturer and later as Professor of Mining, resigned last summer to give his whole time to his work with the Government. Ever since the early days of Cobalt, Prof. Mickle has been a prominent figure in that district as an official of the Ontario Bureau of Mines, as the first Inspector of Claims, later as the Head Inspector of Claims and for the past year as Mine Assessor. He is a Canadian, born at Guelph, educated at Upper Canada College and the University of Toronto, where he took honours in Classics. On receiving his B.A. he took the general engineering course at the S. P. S., graduating in 1888, and then spent two years in post-graduate work at Freiberg. Returning to Canada, he practised his profession as a Mining Engineer for several years at Sudbury. He was appointed Lecturer in Mining at the S. P. S. in 1894, and Professor of Mining in the University of Toronto in 1905. His summers were spent in the field in mining and exploration work in British Columbia, on Hudson's Bay and in other parts of Canada and the States until 1904, since when he has been with the Bureau of Mines. As Inspector of Claims he had to bear the burden of the difficulties encountered in the enforcement of the inspection clause which was so rigidly carried out in the Cobalt area and which played so important a part in the locations of that district. As the area increased and a large number of inspectors were employed, Prof. Mickle was placed in general charge of their work. Eighteen months ago he was appointed Mine Assessor and after carrying on this work jointly with his University work for one year, this work claimed all his time and he resigned his position as Professor. He is the second professor to join the Bureau of Mines. Dr. Miller, the Provincial Geologist, was also won from the academic life, he having been Professor of Mining at Queen's for some ten years. Conditions have not permitted such an extensive growth in the Mining department of the University as for example in the Mechanical and Electrical departments, but Prof. Mickle has built a splendid foundation for metallurgy and for mining. The laboratories in these departments, though not so heavily equipped as others of older growth, will hold their own with any in the Dominion in the possibilities of their teaching functions. The foundation is laid down on safe and broad lines and competent judges have

expressed their satisfaction at the unselfish, broad-minded way in which these were laid, the funds available being spent entirely on fundamental essentials that often lent no outward lustre to his department but which meant much for the future. His career in the S. P. S. was marked by sterling loyalty and this same spirit has characterized his work in the field. The Government Department of Mines has given him the most difficult positions in their work; positions that require the most careful judgment, where decisions must be rendered that must be unassailable not only in their knowledge of mining but in their absolute fairness and impartiality. Had Prof. Mickle not left the academic life the Government would have been hard put to it to have found a man to fill his place in the field, and if the School has lost a valued colleague and friend, the Government and the field have gained a man whom most men like and whom everybody respects and admires. He is still in Ontario and will often be consulted in the policy of the School.

H. E. T. Haultain

H. E. T. Haultain is a Canadian by education and adoption. He was born in Brighton, England, in 1869, but was taken from England when only three months old. He was educated at the Public School and Collegiate Institute at Peterborough, Ontario, and graduated in the regular course in Civil Engineering at the School of Practical Science in 1889. He was prizeman in his first year, secretary-treasurer of the Engineering Society in his second and president of the Engineering Society in his third, being the first student president, succeeding Prof. Galbraith, who had been president during the first years of the Society.

On graduating he went to England and joined a mining engineer in London practically under the English form of pupillage, and was sent by him in charge of small operations in the South of Ireland, and afterwards to the St. Mauritius tin mines in Bohemia. While here he designed and operated the first electric mining hoist on the Continent of Europe (end of 1890). He subsequently took post-graduate work, first in London and then at Freiberg, and in 1893 joined the late Maurice Bucke in British Columbia and has been engaged in mining work ever since, in British Columbia, South Africa and several of the Western States. He returned to Ontario in 1905 to take charge of the Canada Corundum Co.'s works at Craigmont. His specialty is the mechancial treatment of ores but from the academic point of view his important specialty is the variety of his experience. He has held all positions from that of laborer with pick and shovel to that of general manager. He has worked all over the world in ores of tin, copper, silver, gold, lead, zinc and corundum. He has always maintained a high professional tone and of late has taken an aggressive public attitude against the wild-catting in Northern Ontario. He is a member

of the two English exclusive technical societies, being an Associate Member of the Institution of Civil Engineers and a Member of the Institution of Mining and Metallurgy. He is a Member of the Canadian Society of Civil Engineers and a Member of Council of the Canadian Mining Institute and holds the degree of C. E. of the University of Toronto. His appointment to the only chair of Mining Engineering in this University was confirmed on October 8th last under the title of Associate Professor.

When asked why he deserted the field for the academic life, he replies that he has not entirely deserted the field, that he hopes there is room for both academic and field work and quotes from Sir Alexander Kennedy's presidential address to the Institution of Civil Engineers:

"It has been, no doubt, a source of regret to many, as it is to myself, that as years go on and experience accumulates, one's work comes always more and more to deal with men and matters, with general schemes and methods, even with financial means and possibilities, and less with the directly mechanical problems which fascinated us when we were younger, and for the sake of which—probably—we took to engineering at all in the first instance."

"The resignation of Professor George R. Mickle from the Professorship of Mining in the Faculty of Applied Science of Toronto University, in order to more closely identify himself with the provincial administration of the mining industry, has made it possible for his successor to be Mr. H. E. T. Haultain, a thoroughly equipped, admirably-poised, versatile, British born, Canadian bred and cultured, engineer. To succeed Professor Mickle, who enjoys the respect and confidence of higher educational authorities and mining scientists, is in itself an honor. Had Mr. Haultain not been what he is the selection might have brought to him the onerous task of measuring attainments with his predecessor. It is such exchanges, in which the Ontario Ministry and Toronto University Faculty have been happily fortunate, which give substance to the expectation that the mining sciences of Canada are to be exalted beyond mercenaries."—The Mining Journal (London).

The Demand for Research Work

It is felt throughout the undergraduate body in Applied Science that more adequate provision should be made for those who desire to follow up their regular course by an additional year on research work. Of course under the conditions now existing with present equipment, post-graduate work in many of the courses is impossible. But this is not true of the mining and chemical courses, and no doubt much good work might be done in many of the other departments.

What, then, deters the men who may be desirous of extending their knowledge of any particular branch, from putting in an extra session's work? Granting that work could be done in the laboratories if such were requested, why is there no desire on the part of the graduates to continue investigations they may have begun? No doubt such desire on the part of the graduates does exist, but certain factors must be changed before there will be visible expression of that desire. No incentive now exists for a man to take up post-graduate work except his own interest in the investigations, and while this should be of paramount importance, still there must be some other goal in sight than the mere feeling of having thrown some new light on an old subject.

It is not intended to criticize present conditions, for it is understood that what at present exists is a result of past policies, but these observations are now offered in the light of the fact that the four year course will soon be an accomplished fact and as an expression of a strong sentiment among the graduates that something must be done in the immediate future.

Under the new regime, a strong interfaculty spirit is being developed throughout the University which is tending towards a sympathy of action and a unity of aim and purpose, and is gradually eliminating any sectional prejudices which may have heretofore existed.

If this feeling is to be fostered, there must be just and equal treatment to all, and this treatment may have to be granted perhaps at the expense of traditional rights and privileges.

Aids to Research in Other Faculties

A comparison with what is done towards rewarding a man for additional or post-graduate work, in other faculties, with what is done at the School, will be instructive. In the Arts faculty, a man who has shown capacity for original work may be granted a fellowship with a salary of $500. At the same time while holding this fellowship he is allowed to take a prescribed course of work, including lectures, and write off an examination leading to the degree of Master of Arts. And if he shows exceptional ability he is permitted to hold the fellowship for two more years and proceed to the degree of Doctor of Philosophy, during all this time following a course of lectures laid down by the University.

Disabilities for Research Work in Applied Science

For many reasons this is impossible for a graduate of Applied Science to do. First, his whole time is required of him for the accomplishment of the academic work allotted to him, and again no lecture courses in the University which deal with his work, are arranged for. Even supposing he were allowed a portion of time for work other than that allotted to him, still he would have no reason for following up a subject of interest to him other than the

pleasure he might derive from his work. It is true that the degree of Doctor of Philosophy is now nominally open to graduates in Applied Science, but it is also true that in the list of subjects and courses given, there is absolutely nothing which is either of interest to them or which has the slightest bearing on their work. A glance at the list given in the University Calendar will satisfy anyone on this point. It may be said that provision is made for at least the mining and chemical men in the Ph.D. work, but these departments include an exceedingly small portion of those in attendance and no provision whatever is attempted for the Civil, Mechanical or Electrical men. Even the work which the miners and chemists might take does not approach the end aimed at, in their case.

Lack of Scholarships

Another point of interest in connection with the work in the Faculty is the lack of scholarships. It is appreciated that new conditions have arisen since the closer union of S. P. S. with the University, but the graduates feel that these new conditions require in turn a rearrangement of the old traditions and this rearrangement will not come until it is shown that it is required.

Disabilities of Applied Science

In looking over the regulations respecting scholarships, one is struck by a statement made there, that all undergraduate scholars must sign a declaration of intention to proceed to a degree in Arts in the University, before a scholarship will be granted. Surely a man holding a mathematical scholarship should be allowed the option of a course in the Faculty of Applied Science, for it is here the mathematical men naturally gravitate.

1851 Science Scholarship

Again, the 1851 Exhibition Science Research Scholarship of an annual value of $750 is awarded each alternate year to a University graduate. Under the general regulations governing this scholarship, it is stated that *the scholarship is intended to enable graduates to continue the prosecution of science in its application to the industries of the country.* Naturally, then, this scholarship should be given to the Faculty of Applied Science. In the last ten years, this scholarship has been taken by students of the Engineering Faculty at McGill. But here we do not even find the scholarship listed in the Applied Science Faculty Calendar, but placed in the Arts Calendar. However, in the Senate regulations, it is shown to be open to Engineering students. But let us look at the last award. Last year the scholarship was won by a thesis entitled "On Variations in the Conductivity of Air Enclosed in Metallic Receivers," and "On an Improvement in the Determination of Visibility Curves"

—*physical researches in pure science.* At the same time were entered two theses from Engineering students and one of these was on "the Discovery of a New Process of treating Cobalt Ores." No doubt from a pure science standpoint the first rightly won the scholarship, but considering the intention for which the grant was made, as an incentive for research of an industrial nature, the second certainly merited consideration.

In the light of the above facts, what changes should be suggested? It is the opinion of many of the graduates that post-

Conclusions

graduate work should be allowed men who are holding fellowships, and a new Master of Science degree established, to be granted after a year's post-graduate work and under the same conditions as the M.A. degree; that the Ph.D. degree be made applicable to Applied Science graduates; that the 1851 Science Scholarship be handed over to the Faculty of Applied Science, or at least the intention of the founders of the scholarship be more rigidly adhered to, in the consideration of the subjects for theses.

NOTICE—PRIZES OFFERED

To stimulate the interest of undergraduates, a prize of $10 in books is offered in each section for the best paper presented for publication in "Applied Science," such papers to be available for sectional meetings if required.

THE ENGINEERING SOCIETY—OCTOBER

As usual, the first week or two were marked by very heavy work in the supply department. This year sees prices down practically to cost and the gain to the student body has been very material. That this was realized was shown by the very heavy purchasing in the supply department.

The first general meeting of the Society was held October 7th in the large lecture hall of the new Physics Building. Dean Galbraith was warmly received by the men as he delivered an informal opening address. The paper of the evening was presented by W. G. Bligh, C.E., of the Indian Government Service, on "The Design of Canal Diversion Weirs on a Sand Foundation." Mr. Bligh's address proved to be of special value to those of the men who are specializing on hydraulic work, as well as of general interest to all. Several elections were necessitated by the non-return of three officers of the Engineering Society. These resulted in the election of Mr. A. R. Duff, vice-president of Chemists' and Miners' Section; Mr. F. H. Moody, '08, recording secretary; Mr. S. S. Gear, Fourth Year representative; and Mr. L. E. Jones, First Year representative.

Owing to the special convocation of October 21st to confer the degree of L.L.D. on Earl Roberts and Lord Milner, the

regular sectional meetings of the Society were postponed until October 28th. The Civil and Mechanical Sections combined to listen to a most interesting address by Rev. Dr. Crummy, B.Sc., D.D., on "General Engineering Development in Japan." Dr. Crummy, having spent a number of years in Japan, was able to point out many features of engineering which were instructive and in numerous instances highly humorous.

Following Rev. Dr. Crummy's address, a paper prepared by Mr. S. S. Gear, '08, on the "Lackawanna Steel Works," proved of great interest to the men. Plans of the works prepared the men to quite an extent for the visit to the works on the annual excursion.

The sectional meeting of the Chemical Section was addressed by Dean Galbraith on "Steel Manufacture." This address was listened to with intense interest by a large body of the men in anticipation of the excursion.

On Saturday, October 31st, what was probably one of the best annual excursions held by the School ran to Buffalo, some two hundred and fifty men turning out. The excursion was accompanied by Dean Galbraith, Prof. Wright, Prof. Bain, and several other members of the Faculty, and their co-operation as leaders of parties contributed largely to the success of the day. The reception accorded in Buffalo could not have been more cordial. The City Council very kindly granted permission to inspect the fire tugs, harbor and other interesting points, and the City Engineer did all in his power to make the visit profitable. At the Lackawanna Steel Works, Mr. Sheddon, general manager, and Mr. Davis, Chief of Police, gave every opportunity to the men of inspecting the various processes and operations. The hearty thanks of the Society is due especially to Mr. Davis for his personal efforts in supervising the arrangement of the various groups and sections.

We are pleased to note, just before going to press, the enthusiastic meeting of the Engineering Society on Wednesday evening, November 4th, in Convocation Hall. The occasion was the presentation of a portrait of Dean Galbraith to the Board of Governors of the University by the undergraduates and graduates in Engineering of the University and S. P. S. The presentation was made by E. W. Stern, '84, New York, one of the School's earliest and most distinguished graduates, and the portrait was received on behalf of the Governors by Dr. John Hoskin. President Falconer, Dr. Ellis and Prof. Haultain all spoke in a happy strain. The Dean received an ovation on rising to speak, making a characteristic and witty address. The portrait is by J. W. L. Forster, who has expressed most faithfully the personality of his subject. A more extended account is reserved for next issue.

WHAT THE GRADUATES ARE DOING

Mr. W. J. Francis, C.E., who graduated from the School of Science in 1893, and who now has a consulting practice in Montreal, is at present contributing a series of papers to British technical journals on engineering in Canada. In one of these papers published in The Engineer, dealing especially with engineering at Toronto University, he has classified, according to geographical distribution and employment, the graduates of S. P. S. up to and including the class of '04, approximately 500 in all. His fiindings will be read with interest. Canada retains 75%; United States has absorbed 24% and 1% are found in other countries. With employment as a basis of classification it is found that 69% have remained in engineering, 14% have gone into contracting or manufacturing and 17% into other lines. The distribution is as follows:

Engineering:—		
Private practice and employment as engineers.	39%	
Government and municipal engineering work..	15%	
Railway engineering	10%	
Light, heat and power engineering	5%	
	——	69%
Industrial lines:—		
Contracting	8%	
Manufacturing	6%	
	——	14%
General business pursuits	4%	
Educational work and professions other than engineering	13%	
	——	17%
Total		100%

Meeting of Past Presidents

A rather unique meeting took place at the King Edward Hotel, Toronto, on Thursday, November 4th. It consisted of a reunion of all the past presidents of the Engineering Society in the city, together with the present president. Out of the twenty-one men who have held the position, the following responded: H. E. T. Haultain, '88-'89; C. F. King, '96-'97; W. E. H. Carter, '98-'99; E. A. James, '04-'05; T. R. Loudon, '05-'06; K. A. MacKenzie, '07-'08; T. H. Hogg, '08-'09; R. J. Marshall, '09-'10. These together with C. H. Mitchell were the guests of Prof. Haultain at a dinner in honor of E. W. Stern, who had come up from New York on purpose to present the portrait of Dean Galbraith to the University. A very full discussion took place on how the interests of Engineering at the University might be advanced, particularly in the line of post-graduate work. It was decided

to push the matter of scholarships, etc., at some future time. In the meantime it was considered advisable to try to obtain equal footing with other faculties in the matter of scholarships at present in existence. More will be heard of this later.

It is interesting to note the whereabouts of the remaining presidents.

F. W. Thorold, '00-'01, is at present in Toronto, but this was not known at the time.

D. Sinclair, '02-'03, and J. D. Shields, '93-'94, are also in Toronto, but the former was seriously ill and the latter indisposed.

R. W. Thomson, '91-'92, mining engineer, passed through city the previous day, on his way to Nova Scotia to report on a mining proposition.

A. E. Blackwood, '94-'95, is manager New York office of the Sullivan Machinery Co.

G. M. Campbell, '95-'96, is superintendent, power apparatus shops, Western Electric Co., Chicago.

H. S. Carpenter, '97-'98, Dist. Eng., Department of Public Works, Regina.

Thos. Shanks, '99-'00, Department of the Interior, Ottawa.

J. F. Hamilton, '03-'04, D. L. Surveyor and Engineer, Lethbridge, Alberta.

J. A. Duff, '89-'90, J. K. Robinson, '90-'91, W. A. Lea, '92-'93, R. H .Barrett, '01-'02, are deceased.

R. A. Ross, E.E., '90, of the firm of Ross & Holgate, Montreal, a graduate of the School in 1890, has been engaged by the Faculty of Applied Science at McGill to deliver a course of lectures on the Commercial Side of Engineering, dealing with organization and operation of companies; with purchase and sale of materials; with accounting, estimates, specifications, contracts and reports. Mr. Ross' wide experience pre-eminently fits him for such a course of lectures. It is to be hoped the new curriculum in course of construction will provide a similar course at Toronto.

E. S. G. Strathy, '07, has sailed for Porto Rico. He will be on the Engineering Staff of the U. S. Government, engaged on irrigation work.

J. M. R. Fairbairn, '93, formerly C. P. R. divisional engineer at Toronto, and later at Montreal, has been appointed principal assistant engineer of the Canadian Pacific Railway.

W. G. Chase, '01, of the firm of Smith, Kerry & Chase, has removed to Winnipeg to take charge of the municipal power plant for his firm. Mr. Chase had the refusal of the position of Chief Electrical Engineer for the city of Toronto, but preferred the freedom of private practice.

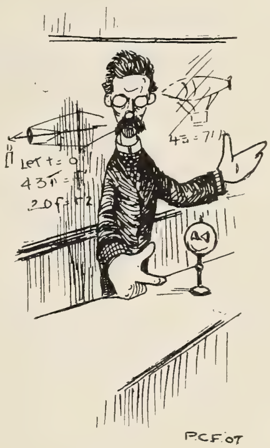
FIVE MEN IN AN AIR-SHIP

(To Say Nothing of Me and the Dog.)

John A. Stiles.

Being the true and authentic record of the culminating triumph of the Science of Ballistics, as discovered and perfected by several professors from the Oriental School of Signs and Wonders.

(Note.—Man can never be considered a complete success in any line until he has sacrificed himself on the altar of his ideal, or in other words, have you the courage of your convictions to such an extent that you would even get inside of them?)



During a lecture on Light as a Force, a small glass bulb containing a miniature windmill was thrust in the path of the lantern's light and almost immediately the mill began to revolve and was soon spinning so rapidly that it could scarcely be seen. Professor Photos claimed that this was a substantial proof that light possessed a remarkable force. Very interesting doubtless, but the dear old professor fell to expanding the idea and to plastering the board with a lacework of equations until I could have thought that we were undergoing a spasm known as the Theory of Probability or wallowing in the slough of Theoretical Astronomy. I yielded to the influence of the soporific atmosphere and was soon adrift in the darkness. For the rest of the period the Rarebit Fiend and I went off on a species of neurotical jambourees.

Now in front of me were two large buildings. From the first issued a loud rumbling noise and from the second a lurid stream of light was directed high into the heavens.

I advanced and was startled by coming face to face with Photos.

"Hello!" he exclaimed, "I am glad to see you taking such an interest in your work and mine."

I wondered what that was, but concluded that he must know the answer.

"The object of my life is about realized," he continued; "a trip to Mars." He stood smiling at me in that benign, expectant way of his, his curly hair rustling gently in the night breezes. As for me and mine, I sang the Scotchman's national anthem. "Hoot mon!" I shouted, and my pulmonary artery swelled within me.

"Now see here," he said, looking off into the distance, as one who sees things the morning after, "Ballistics is the science of throwing massive bodies through long distances, and has as its fundamental law the reciprocal of the famous gravity formula vee-squared over twice gee. I discovered it in the nucleus of its germination during an exhaustive search for a scheme to get more apparatus for my laboratory."

He entered the first building and I followed. I felt as if I had stepped in at the touch-hole of some gigantic cannon, for I had not entered a building as I supposed, but a cylinder some forty or fifty feet long and about ten feet in diameter, which was pointed into the sky at about the same angle as I had noticed the light was directed. To describe it more particularly, it was a large cigar-shaped vessel which was divided into three. Professor Photos made his way to the last room and opening the lid of a large box padded with batting, remarked rather suggestively that it would make a good bed for some one soon.

At last I seemed to realize. "Can it be possible, sir," I exclaimed, "that you are really going to attempt a trip to Mars?"

"Attempt it?" he almost shouted. "I intend to do it, and you shall accompany me."

Accompany him! I almost fainted.

A quick application of two or three of the more general principles of the art of Ju-Jitsu and I found myself snugly tucked away in the padded box.

I blinked blindly and in terror at the big-eyed caricature of Photos as he bent over me fastening a few necessary straps. He seemed quite cool but my heart was beating as one who had been running a dog-churn for his wife, trying to make butter out of skim milk.

"You remember," he continued, "my telling you several times that in the ether that surrounds our atmosphere and takes up the remaining part of space not occupied by ourselves or the United States, there is comparatively little force at work. You understand, there are no wind storms or anything of that kind. Space always remains in a dead calm. I have no doubt if someone could only invent a method of creating a good windstorm in space, that it would wreck the whole universe and send stars, the moon and the planets bumping against each other like forty cats in a fit. Now, my vessel is built first of aluminum, that is the outer walls are of that substance, while next to that lies a layer of mica and inside of that a covering of asbestos. The object of each substance is as follows: the aluminum is made in such a fashion that it can be raised or opened like the slats in shutters. The mica under the aluminum, being transparent, after the asbestos is pulled down, will enable us to see clearly objects of interest, which we may pass. When we are not passing anything we can sit around the sides of the vessel and put in the time reading novels or planning for the return journey."

"But, sir," I interrupted, anxious to make time, "please explain to me how you purpose transporting your wonderful vessel into the ether or space you speak of far enough to be beyond the attraction of gravity."

"Simple as Taylor's Theorem. Newton and I have long ago discovered that the gravitational force decreases directly as the square of the distance. So you see it is merely a matter of distance. My plan is this: Behind and below this building is a large cylinder running underground for over half a mile. This cylinder is rapidly being filled with a fulminate made from the gasefication of the governors' meditations. A meter at the door registers the amount of contemplated force thus being accumulated. Then taking into account the exact coefficient of resistance, which Professor Hydros has kindly worked out for me, I have computed that it will take about steen pounds pressure to the square inch to hustle us without the jurisdiction of this globe. Then what ho! the rest is easy and I'll get my name in the *Globe*. That reminds me, I must see Mr. Marconi about a little matter regarding communication with home. You see my wife will likely be anxious."

"What about air?" I panted. "We must have air to breathe and this vessel will not hold enough."

"Do not worry about that. In the other end of this car stands a drum of vitrified air sufficient to refill these compartments one hundred and fifty times or more."

"The distance—is it not too great to attempt to cross before we shall all be dead?" I asked.

"The distance is a mere bagatelle. You will recall, doubtless, the many lectures I have given you on Light as a Force. Very well; my plan is this: Upon being shot away from the earth an immense light will be turned upon us which will increase our velocity from 15 to 29.995 per cent. per second. A little problem in acceleration for you. You see in space power gained is power retained, and a little mental arithmetic will show you that at the end of an hour's time we shall have attained a speed of seven thousand miles per minute. Then the rest will be easy. All we shall have to do will be to sit there and go, simply go! go! I have got the problem of food and all that sort of thing solved long ago."

The rest was easy, sure enough, for he put a sponge to my nose and the last thing I remembered was wondering whether I would be back in time to take a demonstratorship or not.

A frightful pain in my left arm awakened me. Surely I must be at sea. How dreadfully the ship was rolling! How dark it was! I struggled to get up but found that I was firmly bound. Now I remembered everything. I was out in space careering along at seven thousand miles a minute. There was some satisfaction in the fact that we were going pretty fast. As I lay thus musing, someone opened the lid of my box and I found

myself blinking at the dazzling light of the sun. My next impression was that it was very cold in the car.

"Don't you think it's time you got up?" said Photos. "I don't know what time it is, for my watch seems to have stopped, but I shall call up Toronto in a minute. I want to speak to the Dean. I have just remembered that I have forgotten to get leave of absence and I suppose he'll be properly mad over it." He went to the end of the car and worked a telegrapher's key for a few minutes. Then a moment's wait and he began to write rapidly. "The explosion which sent you into space brought down City Hall tower, also Science buildings; all exams. off. Special meeting of Council. Warrant out for your arrest. Full page article in all papers. Keep us advised. Dean says doesn't see how he can let you go. Great opportunity working for moving picture shows when you return. Time 9.30 a.m."

"Hem," said the professor. "They won't think me so slow after all, will they? I wish the shock had killed a man I know, but that's neither here nor there. At least I mean, thank goodness I am away from him, at any rate. Now I suppose we had better wake the rest, since it is long past breakfast time."

Imagine my surprise to see him open five boxes similar to the one in which I had been imprisoned. Professor Looby yawned, stretched, looked about him, smiled good naturedly, asked if we were out of sight of earth yet, and turned over for another snooze. Professor Walkembust was already awake and anxious to be up. "Good morning," he said, stroking his hairless pate. "How are chances to get something to eat?" Professors Statish and Kemoss were not so easily wakened, the effect of the anaesthetic not having worn off yet. However, by the time the occupant of the last couch had been liberated and pacified all were ready for something to eat. The last named individual being none other than our old friend Tige, the dog. The poor brute seemed to take in the situation at a glance and gazed up into our faces with a look which seemed to say, "Well, I'm next all right, but what's the answer?"

After breakfast Looby opened a paper door and crawled up to the top of the car along which ran a huge telescope. "I shall now determine our whereabouts," he remarked quite cheerfully. His face was not so cheerful, however, a moment later when he slid down from his perch and announced that we were heading straight for the moon.

"Gentlemen, I might as well break it to you at once. Get ready for a bump, for I think there is going to be one. Even now we have covered over half of the distance between the earth and the moon."

Then followed many hours of wonderful events. We all, including the dog Tige, stood gazing through the transparent sides of the car at the objects we were passing and some that passed us. Kemoss remarked with a grim smile that most of the

things we saw were going in the opposite direction to that in which we were inclined to believe they were travelling. Many times we rushed by huge masses of rock, the aluminum sides often brushing them so roughly as to jostle the car. Had they not been travelling in the same direction as ourselves they would have passed us so rapidly as to forbid our seeing them.

A white light was seen before us. Slowly we ran it down. Now we were close behind it. It was a mountain of rock at a white heat. Gradually, very gradually, we gained upon it, and as we did so we became conscious of its great heat. Like a fiend the car seemed to recognise a comrade and was diving straight toward it. The heat became so intense that we were compelled to lie upon the car floor and let down the aluminum flanges. Poor Tige seemed to scent the danger, for between his pantings he would stop to whine and look up into the faces of each of us in turn.

During all the mad race Kemoss had not uttered a sound, but just as the car seemed about to touch its nose to the rock he stepped quickly to the front, took a look, and said, "I think we had better change the air in the car. It is getting rather close in here. I do not think that there is much cause for alarm at our present situation. If you will enter the next room and close this door I will show you how we purpose defeating such fiery friends as that ahead of us." We obeyed. The snout of the car was almost among the flames when the professor opened two valves in the head of the car. A hiss—a roar—an intolerable odor. As Kemoss returned to us and we pulled open the door to receive him the rush of air from our room nearly overbalanced him. A shrill whistling from the valve on the vitrified air drum and the car was once more filled with precious air. We raised the flanges now and all rushed to the head of the car. The rock was gone, having been blown completely clear of our path. We were saved for the present at least. We could hardly avoid the thought, however, that perhaps the next monster would not be travelling with us but against us. Walkembust remarked with a smile that it would have been a quick business

if our friend had been coming to school instead of going home.

It was now about twenty hours since we had been hurled into space and since Looby assured us that we would not be near the moon for another day at least, our speed having so decreased, someone suggested that we take a snooze. I did not feel inclined to re-enter my bed. It was too much like trying to sleep in one's coffin, so I imitated the example of the others and lay down with my feet towards the head of the car.

How long I slept I don't know, but I was awakened by hearing the rest of the company talking excitedly. I rubbed my eyes, got up and gazed about. We were quite near the moon now, very near it, too uncomfortably near. Contrary to our expectations, however, the bump did not come, for we shot past the satellite like a cannon ball. We were standing looking at one another wondering what would happen to us next, when the strange conviction was forced in upon me that our car was not travelling as fast as formerly and I was not surprised to hear Looby say, "I thought so. Now we are going to go back to the moon." True enough, like a shot out of a gun we swept past it again, stopped on the other side and made the return journey, though with less force. The truth of the matter was that we were virtually playing the part of a satellite to the moon, running around and around it like the gyrations of a moth about a candle flame. Our speed decreased. Once we thought we were going to run into another rock, but it proved to be only a flaming bag of gas and we shot through it, scarcely feeling the heat.

As our velocity decreased it became possible to make a more careful inspection of our new home. It was much as we had seen in magazines, spinning always with the same side to the earth. As we shot once more around it we noticed that it was bowl-shaped, the side away from the earth being hollowed out like a walnut shell. We sped back and forth about this strange satellite for two or three hours, but always getting closer and finally tripping over the edge of the bowl and soaring down like a bird. As we were nearing the ground I could have screamed with excitement.

"Down with the flanges," hissed Photos, and they went down with a crash just as the car alighted. There was a tremendous jolt that sent everything, ourselves included, into a heap at the front of the car.

Tige was the first one to raise his voice on the new planet. Something had fallen on him and he was yelping loudly. He was soon located and bounded about over everybody and everything in the dark. Then began a rummaging among the debris for the box with the tapers. We succeeded after a time in getting a light and proceeded to take stock of our mixed merchandise. The partitions and everything belonging to them had

been swept away, but notwithstanding the great crash the car was even now air-tight.

Outside we could hear a light tapping on the car and directly above our heads we noticed a sound as of some one drilling. To this part Professor Statish gave his whole attention, murmuring something about the horizontal resolved part of the resultant. Mounting on a box he listened intently. The drilling continued for some time, probably an hour, when finally the professor's vigil was rewarded. The sharp point of a green-colored instrument pierced the mica. The professor immediately seized and held it and instructed me to mount on his shoulders and ascertain if possible, by peering through a crack in the flanges, what sort of a creature was doing the damage. By the aid of a piece of glass I was at length enabled to catch a glimpse of the figure, which was crouching on the roof of the car trying to withdraw the tool. It was a creature about four feet high, pearl-colored and shone in the sun, as if it had been highly polished. It was proportioned exactly like a man and I noticed that it had no hair. In fact there did not seem to be room for any hair, for a row of rabbit-like eyes ran completely round its head. At first I was inclined to think it had no ears, but a moment later I discovered that it had one nearly as large as a saucer placed exactly on top of its head.

The professor now released his grip and the boring tool was jerked out, but immediately upon its being withdrawn there was a rush of air. I saw the pearl-colored creature duck his head as if to listen to the noise and then away he flew high into the air kicking and squirming. The hole was quickly closed by placing pieces of paper over it.

Descending from our perches we now held a council of war. There was no doubt about it, the Moonites were evidently very curious or else were openly hostile.

"I tell you what," said Statish, "I know something about the horizontal resolved part of the resultant. When that little beggar drilled an opening through our roof the air cooped in the car puffed him high sky. Well, I advocate cutting similar holes on all sides of the car. Let us cover them with pieces of paper and then raise the flanges. As soon as those creatures see us they will likely make a charge and clamber all over the car and when the car is well covered with them we will pull away the paper."

"A very good idea," assented everybody, "though it is strange that you should have thought of it since your science only deals with stationary bodies and that makes a noise like dynamics."

"You're all wrong," said Photos. "It makes a noise like the Science of Ballistics and I am the one that should have thought of it."

"Well, well, don't quarrel, gentlemen. Let's get to business," said Walkembust.

Immediately we began cutting small holes in the mica with our knives and soon had one hundred and fifty holes made and each covered with several plies of thick brown paper.

"Now, up with the flanges." Up they went and the car was once more flooded with sunlight, which so affected our eyes that we were unable to see for some moments.

When our eyes had gained sufficient strength to bear the light, a scene was unfolded before us which was somewhat startling. At two or three hundred yards distance stood about a thousand of the pearl-colored men, glistening like so many granite tomb-stones. Picking up a telescope, I directed it towards the crowd. It was composed of beings similar to the one we had first seen. Their hands and feet were shaped like cups. Suddenly they turned and rushed towards the car.

As they came forward we perceived that they each carried strange instruments which resembled egg-beaters. They were rapid runners and soon reached the car, clambering over it like a cloud of locusts. The mica was several inches in thickness and while they were boring we charged the car well with air. Then stationing ourselves about the car we began jerking the paper from the holes, replacing the pieces immediately. As each aperture was uncovered there was a zip of the escaping air and one and sometimes two of the Moonites were hurled high into the air, to alight some twenty or thirty feet away apparently uninjured but not anxious to repeat the experiment. Pop! pop! pop! Away they flew like toy balloons, alighting some head first, on their backs or rolling over and over like empty baskets chased by the wind.

Photos now unlocked the sliding door and for the first time in six weeks we stood on terra firma. It occurred to me that Tige might like a scamper as well as ourselves, accordingly I opened the door and let him out.

"Phew! we should have tied a stone to Tige to keep him down," said Kemoss.

Big Tige went crazy for the time being. With two great bounds he was close to the group of Moonites. One more and he had sailed completely over their heads. He turned quickly and jumped at them again. Whether he had made up his mind to devour the whole tribe or not I cannot say, but at any rate he had to exercise great patience before he could get near enough to even get a sniff at them. Each bound sent him twenty yards farther than he intended to go. Nor could he seem to understand, for he flew over and over the terrified creatures, and his barking sounded like the roar of a hundred cannon. At last it seemed as if the Moonites could stand it no longer and we were surprised to see them all standing on their heads, their one ear buried in the loose yellow sand. We noticed that as we spoke to

one another our voices sounded ten times louder than was natural and over and above all sensations was an all-pervading odor of Welsh rabbit. At times it was almost stifling. The ground on which we were endeavoring to walk was like flour but was a kind of chrome yellow. We had scarcely time to consider this when Tige, having given up pursuit, came sailing back to us like a toy balloon in the breeze. With a frightened yelp he went careering over car and all. He now seemed to have an inkling that something very peculiar was the matter and turned and commenced crawling very slowly along the ground to us. We caught him and tied him to the car door. Our enemies had now resumed their former upright positions and began rubbing and pushing one another with their cup-like hands, but we heard no sound from them. Considering that they had learned enough of our powers, we ventured to move a little away from the car. "Great guns! here they come!" shouted Photos, his voice almost deafening us. "What shall we do? We have not a thing with which to hit them and we are cut off from the car." However, as we hesitated the solution was shown us by Tige. About a hundred of them had made toward him. He rose to the occasion and although tied to the car succeeded in raising car and all in a great bound. Finding that he could not fight thus encumbered he contented himself with waiting for the others to assail him. Ten of the bravest charged him with their egg-beaters. Waiting until they had advanced to within a few feet of him he barked. That was enough. The dog's breath was too much of a gale for the pale faces and they fell over one another in great confusion. What happened to Tige after that we were unable to say for we had troubles of our own. Hundreds of the Moonites charged us. Professor Statish drew a long breath and stepping forward greeted ten or fifteen of them with a tremendous puff, which sent them all down like nine-pins. It was my turn next. About twenty of the many-eyed creatures came at me. I filled my lungs as I had seen the professor do, but alas! I could not keep from laughing and exploded long before my foes could reach me. It was Kemoss that did the mischief. He was down on his hands and knees trying to bark like a dog and succeeding very indifferently. A moment more and we were in the midst of them. They seemed numberless, climbing over each other in their desire to get at me. Help! Help! I screamed and my voice cleared a space around me for a moment. Then they were at me again and stabbing and drilling at me with their egg-beaters.

It was Kemoss that saved the day. He had fought his way back to the car and returned with a drum of compressed air and a hose. The rest of the battle was as easy as watering the lawn. Swish! Swish! and there was a space clear in front of us. "Save Walkembust!" shouted Photos, who was now struggling toward us, "he is down!" We shouted and dragged the hose after us as we blew a path to where we had last seen him.

Swish! Swish! went the nozzle and the professor lay before us. His face was completely covered with minute red specks. We turned the air in his direction and greeted him with a refreshing breeze that soon revived him.

We could no longer reach our enemies by means of the air blast, so as a last resort I slipped back to the car and let the dog loose. Just the chance that Tige wanted. Barking savagely he rushed towards them, jumping over and over them but occasionally lighting right in the midst of a frightened crowd, knocking them right and left. Within five minutes we made out a party of our assailants coming towards us. They advanced running for some distance, then falling to the ground began working their way towards us on all fours. Occasionally they would stop and wave their handless arms demonstratively in the direction of the dog. At last we understood their meaning and whistled for the dog and chained him up.

We then made signs that we were not anxious to resume hostilities if they would throw down their egg-beaters, which they promptly did and advanced fearlessly towards us. The smallest individual among them advanced at once to Professor Walkembust and began gently to stroke his wounded face and bald head. The red specks left immediately and we were more than surprised a few minutes later to see a luxuriant crop of golden hair and a beard appearing. He was jubilant and was constantly thereafter coaxing us to tell him what he looked like.

It was not long until Walkembust's instincts began to assert themselves and he started walking across country, followed at a respectful distance by the Moonites. We crossed great fissures in the loose yellow ground by simply leaping them, the Moonites going around. Walkembust seemed greatly perplexed at the rock formations and when we questioned him as to their technical name, he said that as time went on he was more and more convinced that it was a species of rock which is usually found in table lands and called Limberg-Silurian. We crossed the bottom of the bowl, so to speak, and were now crawling laboriously up the side to the edge of the dish when I slipped and fell. To save myself I dug my heels deep into the earth and went ploughing down the slope. I was somewhat behind the rest of the party now and was about to redouble my efforts to reach them when the earth beneath my feet smelt so strongly of Welsh rabbit that I yielded to the temptation to taste it. My suspicions were confirmed but I said nothing to anybody.

Having rejoined our party we proceeded up the slope, reaching the top just as the sun was setting behind us. From our new point of vantage we could now make out that which we had seen before our car landed, viz: that the moon was shaped like half a walnut shell. The edge of the shell was fringed with a strange kind of string-like grass, which very much resembled cotton rope. Kemoss, seated in the midst of

this, had pulled a pad out of his pocket and was making a rather careful sketch of the United States and Canada. I asked him if he thought that he could see Toronto. He said he didn't, but ventured the remark that he thought he could see Chicago and pointed to a black mark beside a lake. I looked a moment and asked, "Are you sure it isn't a volcano?" "Quite sure!" he rejoined; "I know Chicago well."

The outer surface of the moon looked like a sheet of coarse canvas that had been painted yellow, something like the old-fashioned bass-wood hams.

Being somewhat fatigued with our journey, we reclined in different postures on the brow of the hill, now watching the affairs of earth and ever and anon looking back into the darkening valley behind us. We were some distance from our car and I for one was ravenously hungry. I whispered this to Professor Walkembust so as not to disturb the rest with unnecessary fears. He looked at me and smilingly whispered back: "If you are hungry why don't you eat? You are fond of cheese, are you not?" I admitted that I only cared for old cheese. "Well," he continued, "this should be old enough for you," and he knocked a corner off a neighboring rock and began nibbling at it. I followed his example. Soon the secret was out and all the party were gorging themselves.

The moon, then, was nothing more nor less than a gigantic cheese. As the Moonites observed us eating the ground upon which we stood, one of them advanced to my side and stooping down touched my forehead gently. I was surprised at the sensation. A quiver ran through me and an impresion in my mind rapidly shaped itself into words which said, "Do you like it ?" The Moonites, then, had no language, but communicated their thoughts from one to the other by the "touch method." Then followed a long conversation, for I discovered that this creature was able to read my thoughts without even so much as touching me. I always was a plain thinker. Professor Looby had adopted different tactics. He had one of the handsomest Moonites on his knee. He smiled at it and it smiled back and fed him with choice pieces of cheese gathered from the neighboring rocks. The dear little creature indeed had a most kissable looking mouth but I didn't think that Looby would do it, but he did. I looked towards the young Moonite and in its row of eyes distinctly read. "Please tell him not to do that again. It tickles. Oh, isn't he awful!"

If the moon was cheese, then this rope-like grass must be

the rind. Calling one of the Moonites to me, I elicited the information that once the moon was round but that it had all been eaten away until now little more than the mere shell of the original moon remained.

We spent the night on top of the edge of the bowl and in the morning were awakened from a short nap by hearing Tige's barks. Convinced from the noise that he was making that there must be something unusual the matter, we hurried back to the car and a sight greeted our eyes that was more than ordinary even for this strange country. The car was completely surrounded with the most peculiar looking animals. They looked like immense white snakes. They were covered with long, straggly hair and deep wrinkles. As we approached waving our arms and shouting they jumped away. I say jumped away because that was what they literally did, for their mode of locomotion was beyond description, though done something after the following fashion : When one wished to change its position it placed its head on the ground, arched its body and brought its tail close to its head, then with a tremendous bound went spinning through the air. As we were gazing at them in terror I noticed Walkembust smiling. "Don't you know what they are?" he asked. We all admitted that they were a new variety of snake to us. "They are not snakes at all," he laughed. "They are skippers."

The following days were all filled with pain and trouble. We had nothing but cheese and fresh skippers to eat. First Tige took sick and died; then Looby startled us by saying that his nose itched so terribly that he could scarcely stand it, and we realized that it was the result of eating too much cheese. Oh, it is too terrible to tell in detail. One by one all of our party was wiped out, dying of that terrible disease known only in the moon. "itchy nose." Died of cheese and were buried in cheese.

As for me, when Photos died, the thought that his examinations would all be called off was too much for me and I awoke from my dream to find the lecture on Light as a Force still in progress and the board about a foot deep in equations.

J. Galbraith

From painting by J. W. L. Forster

APPLIED SCIENCE

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Published Monthly during the College year by the University of Toronto Engineering Society.

Editorial

This issue completes the second volume of Applied Science and closes one of the most successful years of the Faculty of Applied Science and of the Engineering Society. Several decided advances have taken place in each. The new laboratories for thermodynamics and hydraulic will be practically complete by fall and fourth year difficulties will be to a great extent solved. Keen disappointment is felt, however, as the impression grows that the Board of Governors are not going to take any steps towards a new Engineering Building.

We wish to take this opportunity of thanking our contributors for the valuable assistance they have afforded.

Next year plans are already laid to make Applied Science bigger and better than ever. The co-operation of all the graduates is earnestly requested.

THE STUDY OF ENGLISH LITERATURE IN AN ENGINEERING COURSE

W. B. REDFERN, '18

(1). While engaged in academic work as a student of applied science and engineering, one sometimes considers the advisability and practicability of introducing into our curriculum a course of lectures on the study of English literature, and bearing on this very important question, these few remarks are directed. Let it be understood that this article is not one of protest or dissatisfaction, but rather is it one of suggestion on account of interest in the general welfare of this faculty.

The curriculum at the present time gives us a comprehensive and thorough training in that particular branch of engineering that we are studying, almost entirely from the mathematical and scientific standpoint. We study mathematical subjects as Algebra, Trigonometry, Analytical Geometry, Calculus, etc., and we study scientific subjects as Statistics, Dynamics, Astronomy, Thermo-dynamics, Hydraulics, Theory of Construction, etc. Such a course of studies tends to develop a highly accurate type of mind—a type of mind that wishes and must know the why and wherefore of everything—a type of mind that demands facts, absolute facts, and the causes and effects of the same. As the vast natural resources of Canada become more evident day by day, just so the need for men capable of developing these resources with the best possible results for Canada also increases. And further a country whose population is growing by leaps and bounds is certain continually to present new mathematical and scientific problems for the solution of which all the powers and intellects trained to perfection to deal with such subjects are emphatically needed. Consequently in the efficient and economical development of these resources such a type of mind as above mentioned is required, and will find great scope for the exercise of its faculties.

But need that type of mind be purely scientific and mathematical? Not at all—it may also combine the culture and breadth derived from studying subjects of a nature, not mathematical and scientific, but of a nature entirely different—literary and etymological. In the study of classics and the modern languages entirely different faculties are trained and developed than in the study of the accurate subjects of mathematics and science. In the former case the mind is not constrained to keep within a certain well defined limit of thought and argument, but it may branch out and devote its energies in channels of thought and argument where there is a much greater freedom and latitude. There are no hard and fast limits, but there are excellent facilities for the exercise and development of the imaginative and creative powers, the training of which are even eventually so necessary for engineering design. A piece of translation or an

idea may be expressed in a dozen different ways, all equally good but yet following no well defined limits of expression. Of course, no thought whatever is entertained of introducing classics into a course of engineering, although even a transitory knowledge of them is of some value, yet practically the same faculties are involved and developed in the study of English literature as are involved and developed in the study of classics and of the modern languages.

Graduates in engineering upon entering the practical work of their profession wish to guard against the curse, or "bête noir" of professionalism to-day—narrow-mindedness. We hear that it is so easy to "get into a rut" and so difficult to get out of it. The surest and best way of avoiding narrow-mindedness is by frequent indulgence in desultory reading. If one confines himself in his reading to engineering subjects only, naturally his mental vision will not only carry him beyond the horizon of engineering problems and of engineering accomplishments. Hence, if our studies while at college are as comprehensive and inclusive as possible, our mental vision will be extended far beyond the horizon of our profession, so that we may see and understand things that otherwise would remain incomprehensible and imperceptible to us. It is as if we ascended the mountain of culture and knowledge farther, by so doing greatly extending our mental scope and vision. Our sympathy for humanity would be broadened, and instead of being students in engineering only, we would become students of affairs, and accordingly we would be more serviceable to the community in which we live. Therefore if a course of lectures in English literature were introduced into our curriculum, and greater intellectual discipline and culture that we would acquire would develop in us a much higher mental efficiency, a deeper sympathy for humanity and a much broader outlook on our profession.

Francis Bacon has said,—"Reading makes a full man." And it is not only essential that we should read, but it is even more necessary that we should understand what we read, that we should "digest" what we read. To be able to select the best literature written by the greatest and best men and women who have ever lived, and to be able to understand it requires guidance, training and study. Also to recognize and appreciate a good author's particular style of writing and to detect and discriminate his fine shades of meaning requires guidance, training and study just so surely as these are required in the design of a bridge or in the location of a railway.

Where, then, are we to look for this training and study, so essential and important? Most of us have not attended a collegiate institute long enough to acquire this knowledge and culture. So up to the present time it has been necessary for all who were desirous of becoming conversant and familiar with English literature and the English language to do so entirely apart from their academic work. Then again our academic work

requires so much time of the average student that very little remains to be devoted to these outside studies, unless he is an omnivorous reader and is determined to find time "come what come may." A stream cannot rise higher than its fountain. Consequently to remedy this defect, to meet this need and to place our graduates on a higher pedestal in public opinion, the study of English literature would do much to attain this end.

Also even from a purely professional standpoint, great personal benefit would accrue to those who have an opportuity of studying English literature and the English language in connection with their college work. Some one has said that language is a "vehicle of the engineer." It is certainly indispensable in his profession. He must be familiar with it, because he must use it every day. In drawing up specifications, in writing reports, in engineering correspondence and in many other ways, he must always have the language at his command. These then are other important reasons why this departure would be desirable and advantageous.

In conclusion, since we are now an integral part of this great university, working in conjunction with the other faculties for its common good, and since a four-year course for graduation is about to supplant the present three-year course, could it not be amicably arranged to introduce into our course in Engineering and Applied Science a series of lectures on English literature for the good of our faculty and for the good of the University as a whole? The time is opportune. If not, why not?

A CRUISE—A RETROSPECTION.

HYNDMAN IRWIN, '09

[Note.—The class of '09 needs no further mark of distinction. Its curve is high and prominent on the efficiency-time diagram of the Faculty of Applied Science. But before falling down the stairs for the last time, our regard for the other years necessitates a portraiture of this Chapter of the Order of the T-Square.]

On a fair autumn morning in 1906 the renowned class set sail upon the sea of college life in the channel of Applied Science. Our first assemblage in an upper deck apartment was for instruction regarding the manipulation of the lead pencil and the two-foot rule. During the initial week we raised the old flag of yellow, blue and white; and later chose as our captain, "Ginnis" Johnston. On a pennant at the stern was our "Che hee."

Barely had we put forth to sea when, without warning, the crew were called to arms to decide ocean supremacy. This resulted in our being gloriously victorious, the sacrifice of

EXECUTIVE OF GRADUATING CLASS

O. T. G. Williamson — C. Hughes — H. W. Tate — G. Morton — W. S. Collinson

C. O. Hay — T. H. Crosby, Pres. — Dr. W. H. Ellis, Hon. Pres, — G. R. Workman — W. J. Johnston

breath and clothing being nothing compared with the glory of the beautiful new war balloon, which was finally forced to enter our domain through a window of the engine room.

The ship was manned by two hundred and eighty-eight tars. At the end of the first voyage, however, a few were induced to remain behind, enticed by an easy landing in Real Estate, a comfortable resting place in an Arts harbor, or a pleasant (?) outlook from a Medical haven. Although the prospect was not entirely one of pleasure, it has not proved a tedious journey by any means. It may be that a few sought pleasure only in the trip. Moreover, it was rumored upon decks that one considered it too lonesome, and changed to a canoe that was built for two. Any one of the boys in our navy will testify, however, that there has been a great deal of fun and pleasure, apart from hydraulics, as applied to the incoming freshmen, or experimental optics, as studied from the upper windows, the incident ray being cast upon pretty forms that harmoniously float by, casting reflecting rays, normal to the focal plane. The main cabin has often been the scene of many amusing incidents especially on the event of the election of officers, when we were frequently honored by the presence of the Admiralty, smoking cherry pipes with us.

After our first furlough, we again embarked, under Captain Campbell, with Dolly Black as first mate, Billy Carlyle as purser, and Cy Danks as our holy man—two hundred and five souls in all, with arms trembling from the many hearty hand-greetings following our five months' leave of absence. Our work about the ship was intercepted here and there by welcomed theatre nights, football and hockey games; while the annual dinners and engineering excursions created a lively interest in the affairs of the college fleet.

Alas! We did not all survive the severe annual April hurricanes, and many were lost in the storm. One hundred and seventy-three of us answered the roll-call when we next headed seaward. We rejoiced to have Crosby piloting our craft assisted by Hay and Workman, with Wilson, Bolton and Duff working vigorously at the helm.

On our journey together we have met many friends and many enemies. With the latter we have had not a few encounters. The barge "Epistaxis" has oftentimes required a reprimand, and so too, a foreign squadron consisting chiefly of blue helmets and large buttons; while we have several times found it necessary to turn hostile towards sister ships belonging to our own flotilla. If we have ever suffered defeat, we have forgotten it, as the truest of subjects should, leaving a record of complete victories.

During the trip we have had many narrow escapes. A shoal that was troublesome, although not dangerous, was Thermodynamics; the Scylla that threatened the destruction of our bark was Spherical Trigonometry; the constant shooting of

electricity from a rosy sky kept the bravest of us in fear and trembling, (and the hungriest of us from assailing our hard-tack.) Geometry—analytical and descriptive—proved a dangerous coast if approached too closely; and we have been wafted from our course many times by chemistry fumes.

Although three years is not a very long time in which to gain fame and honor, still we have done so. At the Intercollegiate meets the Science battleships have always had a solid reinforcement from our ship. The Mulock and other cups, have in turn held our mutual joys and tears. We have furnished many of the players in the great teams in football and hockey. Besides, does not the Pride of Cobalt really belong to us?

What we as a class have not learned in our three years of ocean riding, is hardly worth knowing. We know now, that if little is put into study, much cannot be expected. It is simply the working out of the law of conservation of energy.

As for our leaders, they have cheered us on through waves dark and mountain high, and have gained for us the name of being the best mariners that ever manned a ship. And yet, each captain has made his mistakes. His senses were frequently numbed, in dull weather, by moaning fog horns, which proved to be Harper or Cooch, asking a question, or calling for lights, in the middle of a soporiferous discourse. When he warned us that a storm was brewing, it was generally Hagerman brewing mischief. At all events Ginnis, our star ladder scaler would climb the mizzen mast, or go below, in hopes that there might really be something brewing. Or when our musician, Kettle, began to sing, Fate so likened the music to the wind whistling through Doc. James' whiskers that the captain would send them both below, never forgetting that whistling is an ill omen among seamen.

As for our captain of the past year, a page from the log book describes him thus:

"When Manning the ship he was always Kean, but would never Goad us on toward uncertainties. He frequently granted the crew his permission to visit their Holmes, choosing a season in which neither Frost nor Blizzard could mar the pleasure of their holiday. Whenever Sara wandered from sight, the captain would touch a Bell to summon a Workman, whom he would send to Hunter. Then he would Walker about on deck, where he could Vatcher. If he should be down for a Gray snooze and get a cobb Webb in his eye, he would get Crosby degrees, his anger almost immediately subsiding into thoughts of a Greene nook among the Trees on a shady Hill side, with an issue of 'Black and White' to while away the hours. He did not Carrie a Gunn his only weapon for defence being a Key."

We have always been noted for our good behaviour, progressiveness, and curiosity—and generous, even in regard to the Sophomores, although they have not such a high opinion

of us, a reflection on their taste. We have always done our part in trying to convince the press that we are of the Faculty of Applied Science, rather than of "Applied Silence" and we are grateful to the Sophomores for their aid.

Thus we have sailed, the golden sunlight, the blue ocean, the white wave crests ever being foremost in our minds. Too soon we leave the pleasant scenes, but all go to knock at the same door—that of the office of Mr. World. When he, grim, as Father Neptune, asks us who and from what craft we are, we need not hesitate to reply:

"Toronto, Toronto, Toronto Varsitee!"

And when he proceeds to inscribe our names in the log of the great ship, "The Future," the shades of Chezy and Rankine, and Kerchhoff, and Berthelot, will, for the moment, step aside, and silently weep in the shadow of Remorse, while our hearts will join with dear old College-day enthusiasm, in a mighty

Chee hee, Chee he, Chee ha, ha ha!
School of Science, Naughty nine,
Rah! Rah!! Rah!!!

The attention of all our readers is again drawn to the list of graduates, whose address we have been unable to verify, which appeared in the February issue. Some of these we have located, but the addresses of the majority are yet unknown.